Proton Form Factor Ratio, G^P_E/G^P_M *From* *Double Spin Asymmetries*

Spin
Asymmetries of the
Nucleon
Experiment
(E07-003)

Analysis Updates

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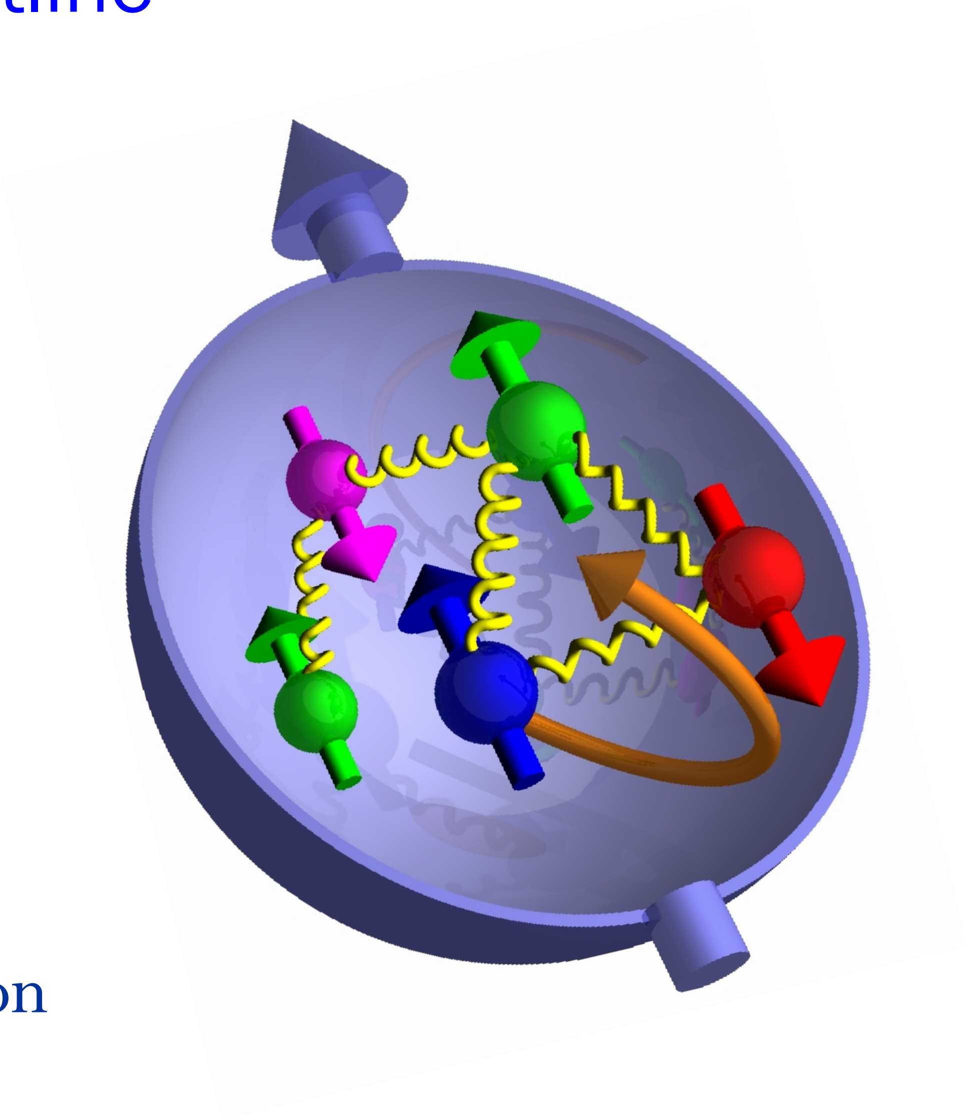
HU Group Meeting
(December 04, 2012)

Outline

- Introduction
- Physics Motivation
- Experiment Setup
  - BETA Detector
  - HMS Detector
  - Polarized Target
- Elastic Kinematic
- Data Analysis &

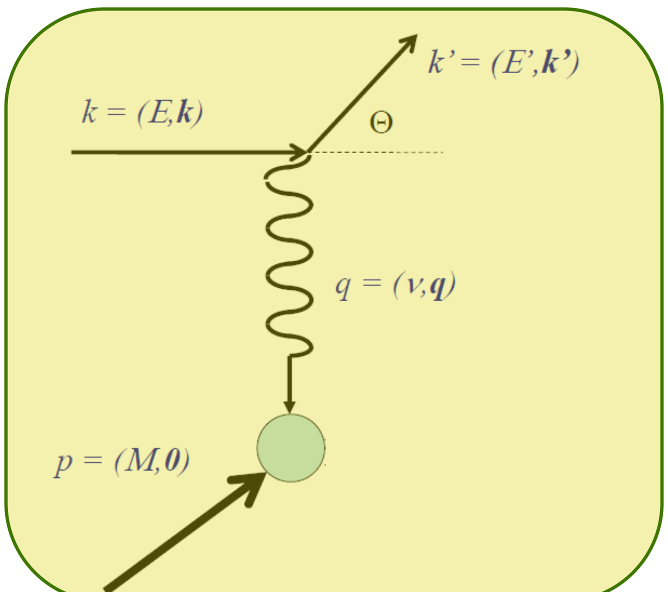
  MC/SIMC Simulation
- Conclusion



Introduction

Nucleon Elastic Form Factors

- Defined in context of single-photon exchange.
- Describe how much the nucleus deviates from a point like particle.
- Describe the internal structure of the nucleons.
- Provide the information on the spatial distribution of electric charge (by electric form factor, G_E) and magnetic moment (by magnetic form factor, G_M) within the proton.
- Can be determined from elastic electron-proton scattering.
- They are functions of the four-momentum transfer squared, Q^2



The four-momentum transfer squared,

$$Q^2 = -q^2 = 4EE'\sin^2\left(\frac{\Theta}{2}\right)$$

$$E - E' = Q^2 / 2M$$

General definition of the nucleon form factor is

$$\left\langle N(P')\middle| J^{\mu}_{EM}(0) \middle| N(P)\right\rangle = \bar{u}(P')\left[\gamma^{\mu}F_1^N(Q^2) + i\sigma^{\mu\nu}\frac{q_\nu}{2M}F_2^N(Q^2)\right]u(P)$$

Sachs Form Factors $G_E = F_1 - \tau F_2$; $G_M = F_1 + F_2$; $\tau = \dfrac{Q^2}{4M^2}$

F_1 – non-spin flip (Dirac Form Factor) describe the charge distribution
F_2 – spin flip (Pauli form factor) describe the magnetic moment distribution

At low $|q^2|$

$$G_E(q^2) \approx G_E(\vec{q}^{\,2}) = \int e^{i\vec{q}\cdot\vec{r}}\rho(\vec{r})d^3\vec{r}$$

$$G_M(q^2) \approx G_M(\vec{q}^{\,2}) = \int e^{i\vec{q}\cdot\vec{r}}\mu(\vec{r})d^3\vec{r}$$

Fourier transforms of the charge, $\rho(r)$ and magnetic moment, $\mu(r)$ distributions in Breit Frame

At $q^2 = 0$

$$G_E(0) = \int \rho(\vec{r})d^3\vec{r} = 1$$

$$G_M(0) = \int \mu(\vec{r})d^3\vec{r} = \mu_P = +2.79$$

$$\mu \, G_E^p / G_M^p = 1$$

Form Factor Ratio Measurements

1. Rosenbluth seperation method.

- Measured the electron - unpolarized proton elastic scattering cross section at fixed Q^2 by varying the scattering angle, θ_e.
- Strongly sensitive to the radiative corrections.

$$\frac{d\sigma}{d\Omega} = \underbrace{\frac{\alpha^2 E' \cos^2 \frac{\theta_e}{2}}{4(1+\tau)E^3 \sin^4 \frac{\theta_e}{2}}}_{\sigma_{Mott}/(1+\tau)} \left[G_E^2 + \frac{\tau}{\varepsilon} G_M^2 \right]$$

$$Q^2 = 2EE'(1-\cos\theta_e)$$

$$\tau = \frac{Q^2}{4M^2}$$

$$\varepsilon = \left[1 + 2(1+\tau)\tan^2 \frac{\theta_e}{2} \right]^{-1}$$

$$\frac{d\sigma}{d\Omega} \cdot \frac{\varepsilon(1+\tau)}{\sigma_{Mott}} = G_E^2 \varepsilon + \tau G_M^2$$

$$Y = m\,X + C$$

The gradient $= G_E^2$, The Intercept $= \tau G_M^2$,

E - Incoming going electron energy
E' - Out going electron energy
θ_e – Outgoing electron's scattering angle
M – Proton mass

2. Polarization Transfer Technique.

- Measured the recoil proton polarization from the elastic scattering of polarized electron-unpolarized proton.
- Insensitive to absolute polarization, analyzing power.
- Less sensitive to radiative correction.

$$\frac{G_E}{G_M} = -\frac{P_T}{P_L}\frac{(E+E')\tan\left(\theta_e/2\right)}{2M_p}$$

E - Incoming going electron energy
E' - Out going electron energy
θ_{e-} Outgoing electron's scattering angle
M_P - Proton mass

$$P_L = M_P^{-1}(E+E')\sqrt{\tau(1+\tau)}G_M^2\tan^2\left(\theta_e/2\right)$$ → Polarization along q

$$P_T = 2\sqrt{\tau(1+\tau)}G_E G_M\tan\left(\theta_e/2\right)$$ → Polarization perpendicular to q (in the scattering plane)

$$P_N = 0$$ → Polarization normal to scattering plane.

3. Double-Spin Asymmetry.

- Measured the cross section asymmetry between + and – electron helicity states in elastic scattering of a polarized electron on a polarized proton.
- The systematic errors are different when compared to either the Rosenbluth technique or the polarization transfer technique.
- The sensitivity to the form factor ratio is the same as the Polarization Transfer Technique.

$$A_P = \frac{-br\sin\theta^*\cos\phi^* - a\cos\theta^*}{r^2 + c}$$

$$\frac{G_E}{G_M} = -\frac{b}{2A_p}\sin\theta^*\cos\phi^* + \sqrt{\frac{b^2}{4A_p^2}\sin^2\theta^*\cos^2\phi^* - \frac{a}{A_P}\cos\theta^* - c}$$

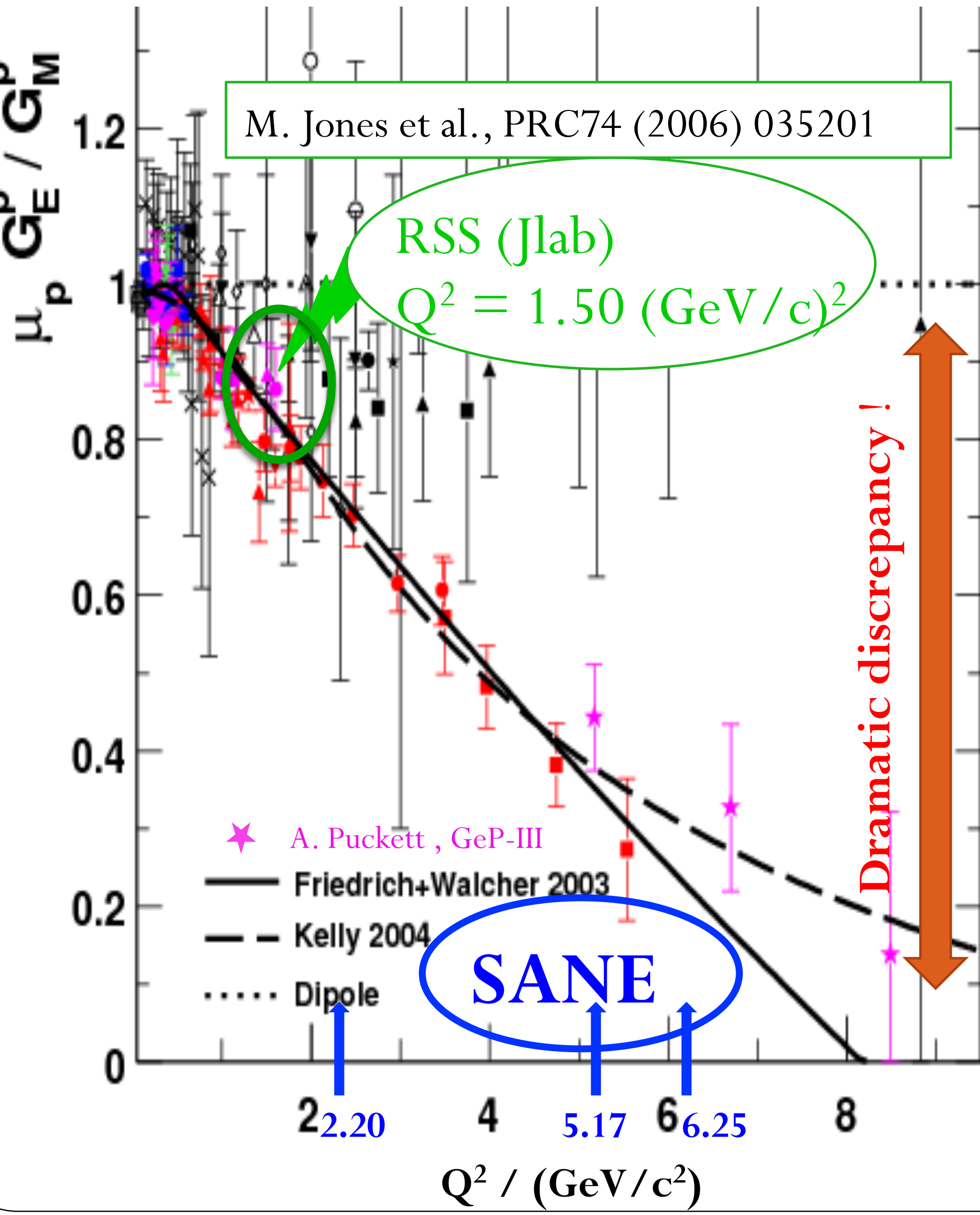
Here, $r = G_E / G_M$

$a, b, c = \textit{kinematic factors}$

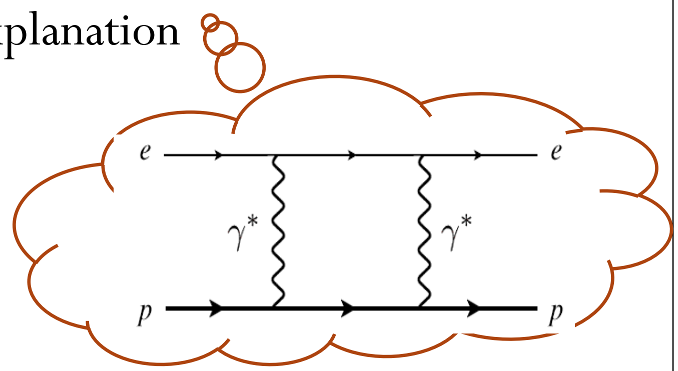
$\theta^*, \phi^* = \textit{pol. and azi. Angles between } \vec{q} \textit{ and } \vec{S}$

$A_p = \textit{The beam - target asymmetry}$

Physics Motivation

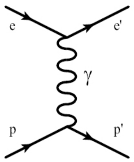


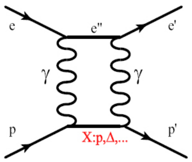
- Dramatic discrepancy between Rosenbluth and recoil polarization technique.
- Multi-photon exchange considered the best candidate for the explanation



- **Double-Spin Asymmetry is an Independent Technique to verify the discrepancy**

Two-Photon Exchange





- Both Rosenbluth method and the polarization transfer technique account for radiative correction, but neither consider two photon exchange.
- Contribution of the TPE amplitude has calculated theoretically and,

  has an ε dependence that has the same sign as the G_E contribution to the cross section and

  is large enough to effect the extracted value of G_E.

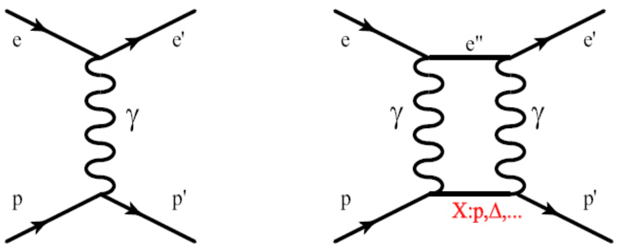
  Therefore, the extracted G_E/G_M for the Rosenbluth technique is reduced.

- The effect of TPE amplitude on the polarization components is small, though the size of the contribution change with ε
- The size of the TPE would measure by taking the ε dependence of the ratio of cross sections, R for elastic electron-proton scattering to positron-proton scattering at a fixed Q^2 and measuring the deviation from 1.

$$R = \frac{\sigma_{e+}}{\sigma_{e-}} = \frac{\left(A_{1\gamma} + A_{2\gamma}\right)^2}{\left(A_{1\gamma} - A_{2\gamma}\right)^2} \approx 1 + 4\,\mathrm{Re}\left(A_{2\gamma} \big/ A_{1\gamma} \right)$$

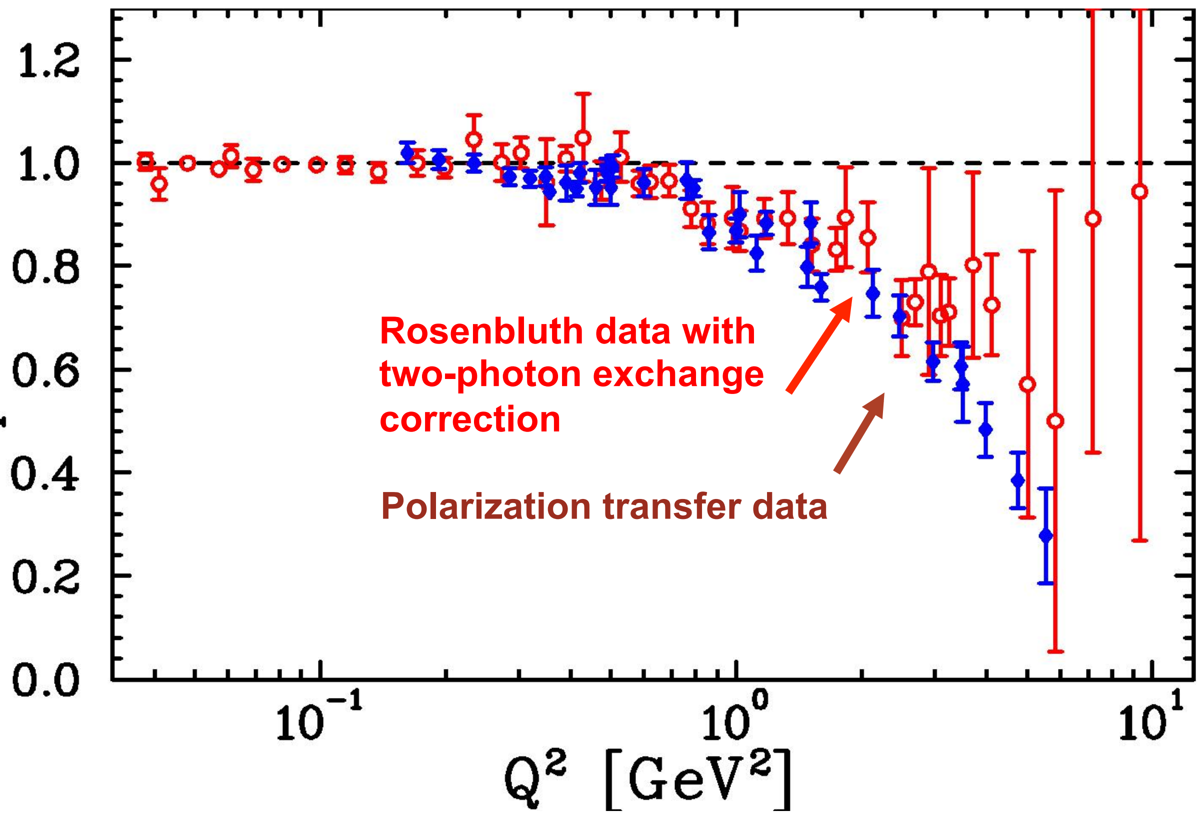
Two-Photon Exchange: Exp. Evidence

Two-photon exchange theoretically suggested



TPE can explain form factor discrepancy

J. Arrington, W. Melnitchouk, J.A. Tjon,
Phys. Rev. C 76 (2007) 035205



Asymmetry measurements

$$\sigma = \sigma_0 + P_E P_T \Delta\sigma$$

⬇

$$\sigma_{++} = \sigma_0 + P_E P_T \Delta\sigma$$

$$\sigma_{+-} = \sigma_0 - P_E P_T \Delta\sigma$$

σ - Scattering cross section
σ_0- Scattering cross section at unpolarized target
σ_B- Scattering cross section from background
$\Delta\sigma$ - σ correction due to the spin
P_E – Beam polarization
P_T – Target polarization
f – Dilution factor

$$\frac{\sigma_{++} - \sigma_{+-}}{\sigma_{++} + \sigma_{+-}} = P_E P_T \cdot \frac{\Delta\sigma}{\sigma_0} = \frac{N_+ - N_-}{N_+ + N_-} = A_r$$

$$\frac{A_r}{P_E P_T} = \frac{\Delta\sigma}{\sigma_0} = A_p$$

Hence,

A_p, known as the physics asymmetry is the relative scattering cross section correction due to the spin.

A_r is the raw asymmetry

With background….

$$\sigma_{++} = \sigma_0 + P_E P_T \Delta\sigma + \sigma_B$$

$$\sigma_{+-} = \sigma_0 - P_E P_T \Delta\sigma + \sigma_B$$

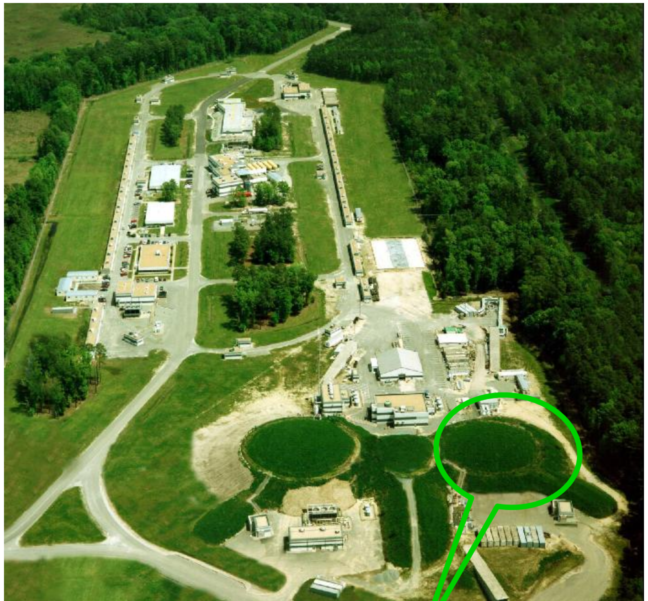
$$A_r = P_E P_T \cdot \frac{\Delta\sigma}{(\sigma_0 + \sigma_B)}$$

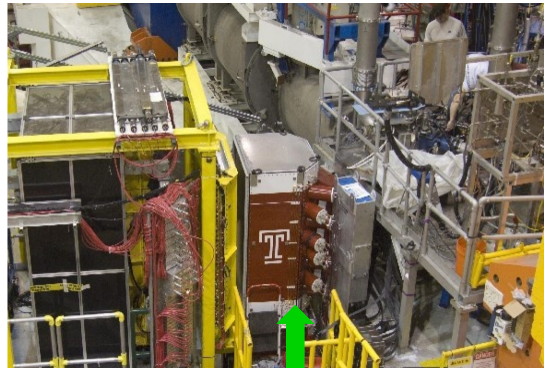
$$A_r = P_E P_T \cdot \frac{\Delta\sigma}{\sigma_0} \cdot \frac{\sigma_0}{(\sigma_0 + \sigma_B)}$$

f

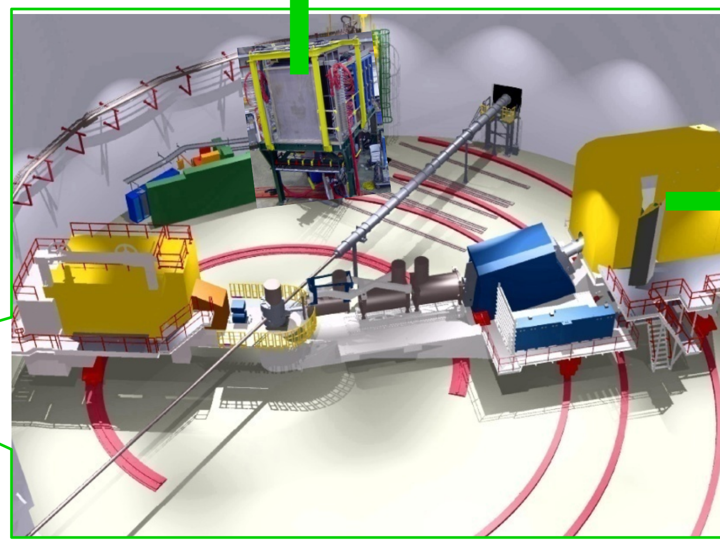
$$A_P = \frac{A_r}{f P_E P_T}$$

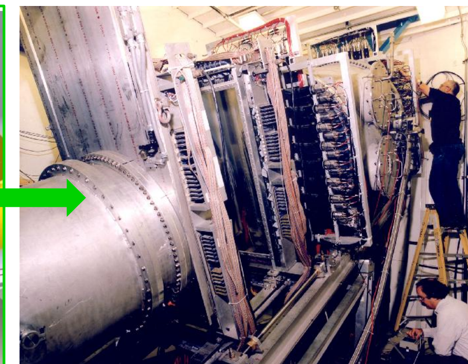
Experiment Setup





- BETA for coincidence electron detection
- Central scattering angle :40 °
- Over 200 msr solid angle coverage





Hall C at Jefferson Lab

- HMS for the scattered proton detection
- Central angles are 22.3° and 22.0°
- Solid angle ~10 msr

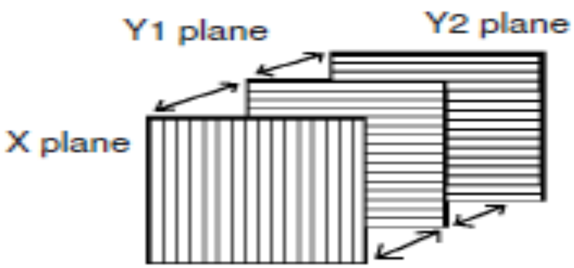
Elastic (e , e’p) scattering from the polarized NH_3 target using a longitudinally polarized electron beam

(Data collected from Jan – March ,2009)

Big Electron Telescope Array – BETA

Forward Tracker

- 3 planes of Bicron Scintillator provide early particle tracking

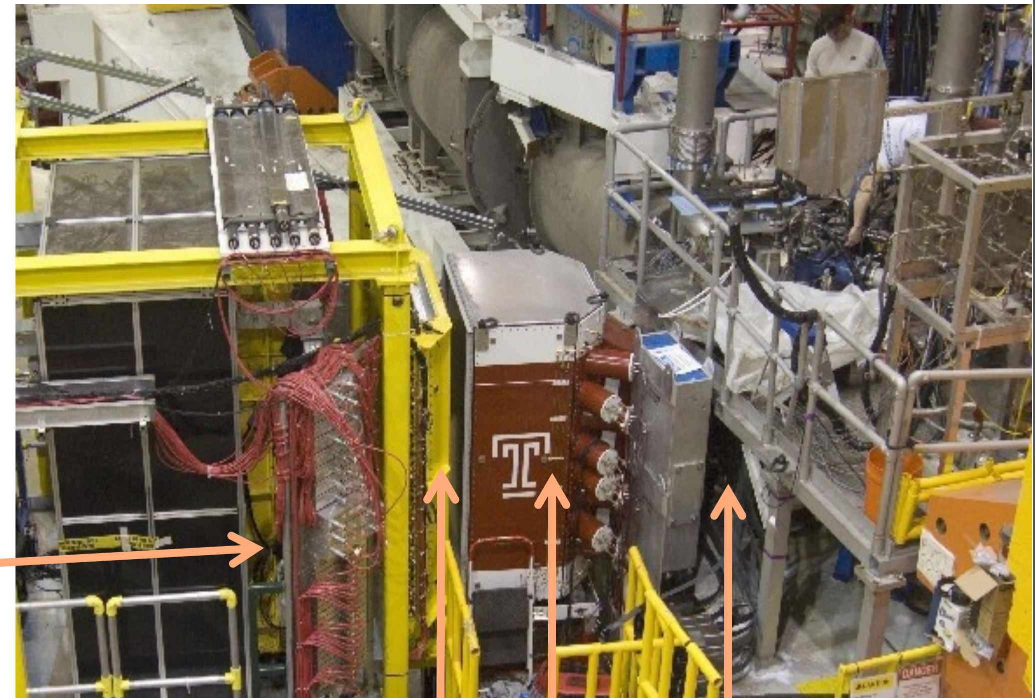


Cerenkov

- N_2 gas cerenkov
- Provides particle ID
- 8 mirrors and 8 PMTs

Lucite Hodescope

- 28 bars of 6cm wide Lucite
- Bars oriented horizontally for Y tracking
- PMTs on either side of bar provides X resolution



Big Cal (GEP III Collaboration)

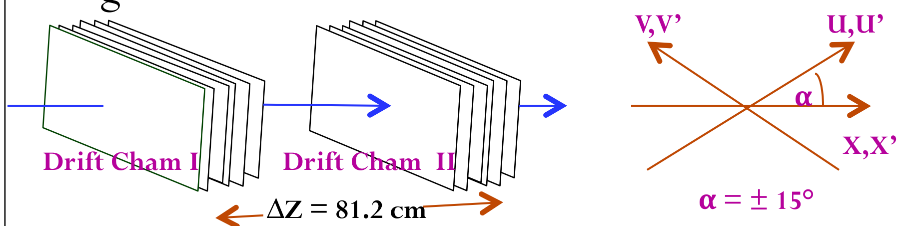
Lead glass calorimeter

- 1744 blocks aprx. 4cm x 4cm
- energy and position measurement

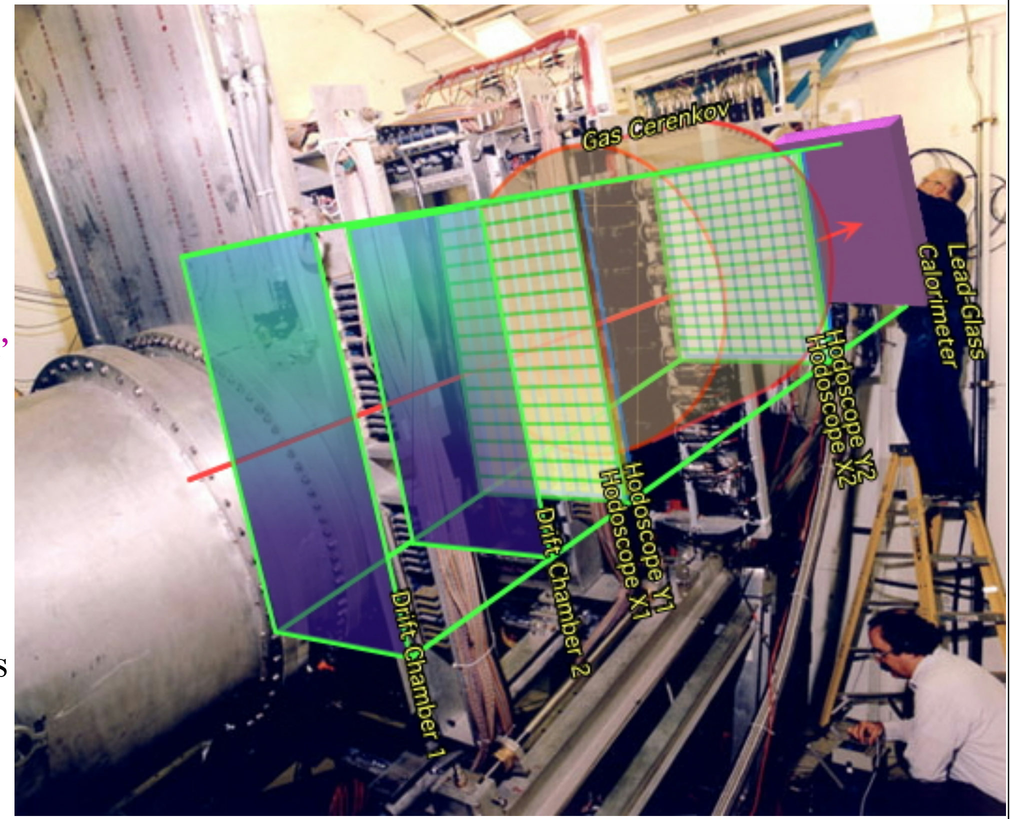
High Momentum Spectrometer – HMS

Drift Chambers

- Each plane has a set of alternating field and sense wires Filled with an equal parts Argon-Methane mixture

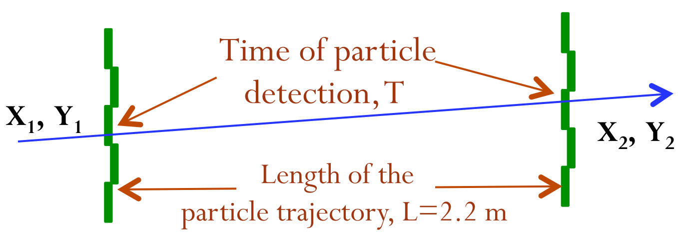


- Track particle trajectory by multiple planes.
- χ^2 fitting to determine a straight trajectory.



Hodoscopes

- Each plane contains 10 to 16 Scintillator paddles with PMTs on both ends
- Each Paddle is 1.0 cm thick and 8.0 cm wide



- Fast position determination & triggering
- Time of Flight (TOF) = T2-T1 determines β

(β = L/c x TOF)

Gas Cerenkov

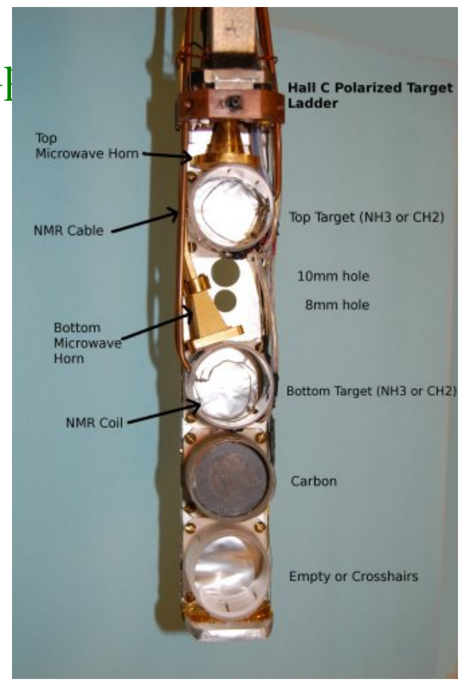
- Two mirrors (top & bottom) connected to two PMTs
- Used as a Particle ID

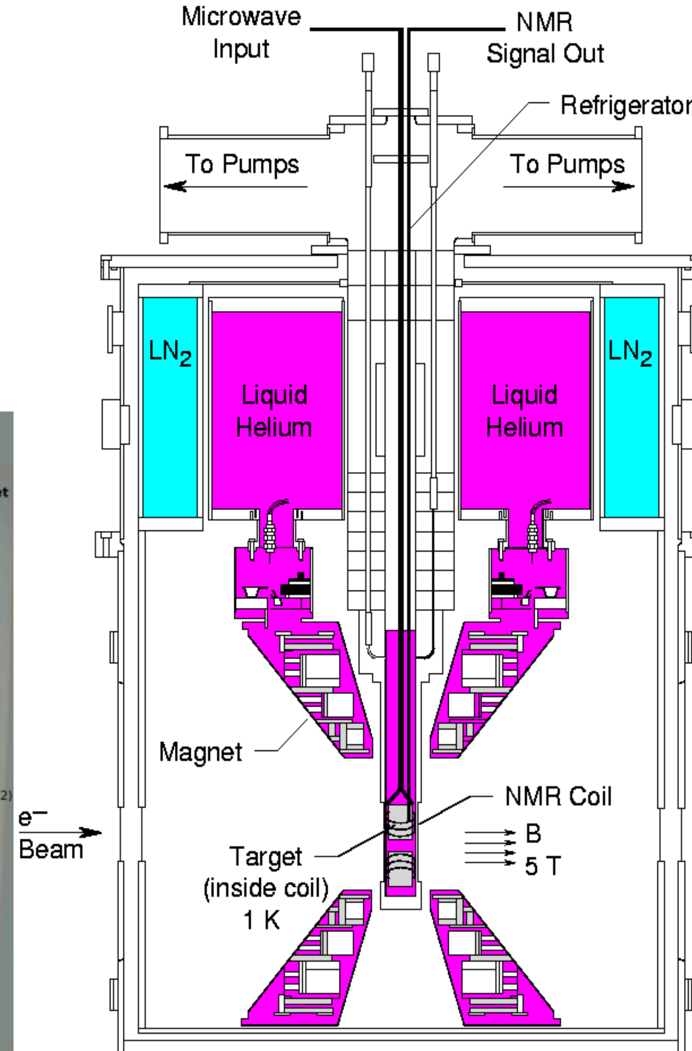
Lead Glass Calorimeter

- 4 layers of 10 cm x 10cm x70cm blocks stacked 13 high.
- Used as a Particle ID

Polarized Target

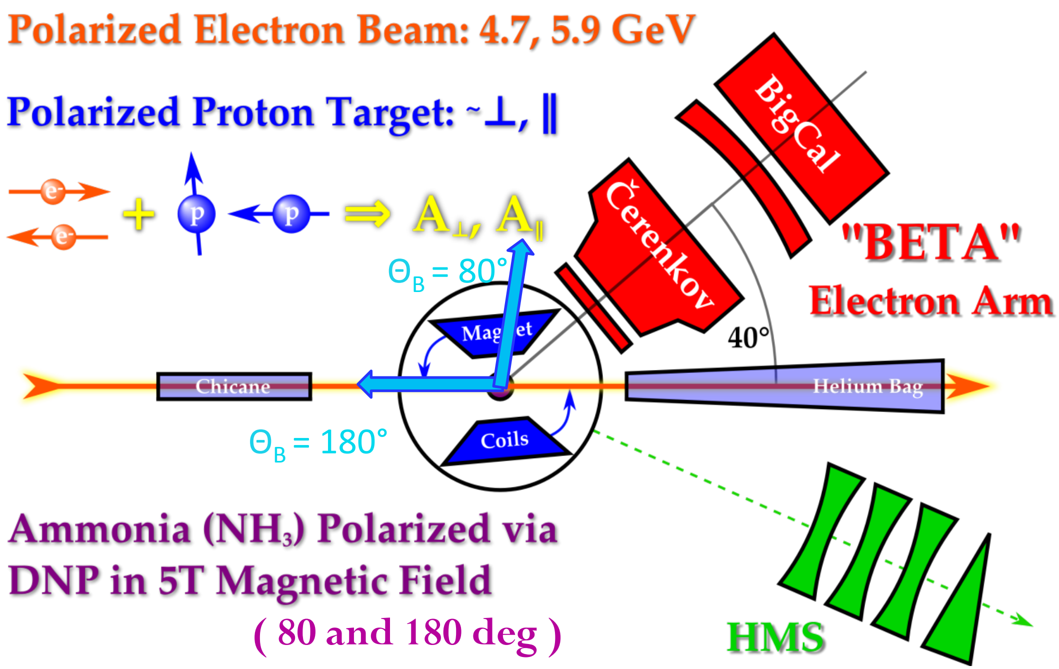
- C, CH_2 and NH_3
- Dynamic Nuclear Polarization (DNP) polarized the protons in the NH_3 target up to 90% at
  - 1 K Temperature
  - 5 T Magnetic Field
- Temperature is maintained by immersing the entire target in the liquid He bath
- Used microwaves to excite spin fli transitions
  (55 GHz - 165 GHz)
- Polarization measured using NMR coils
- To maintain reasonable target polarization, the beam current,
  - ➢ limited to 100 nA
  - ➢ Was uniformly rastered.





The Polarized Target Assembly

Polarized Target Magnetic Field



- Used only perpendicular magnetic field configuration for the elastic data
  - Average target polarization is ~ 70 %
  - Average beam polarization is ~ 73 %

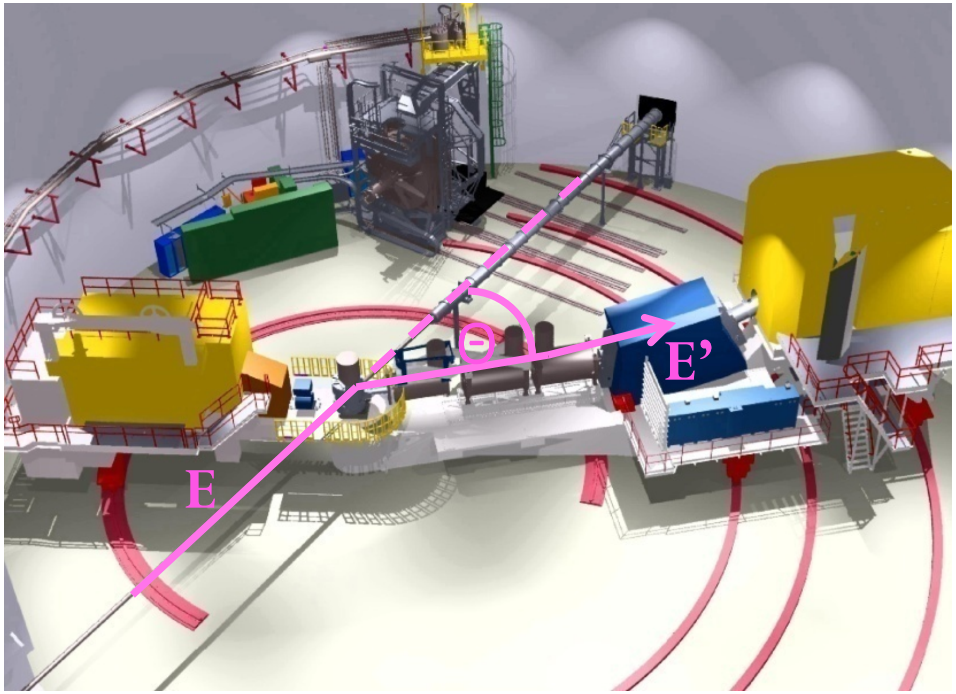
Elastic Kinematics

(From HMS Spectrometer)

Spectrometer mode	Coincidence	Coincidence	Single Arm
HMS Detects	Proton	Proton	Electron
E Beam GeV	4.72	5.89	5.89
P_{HMS} GeV/c	3.58	4.17	4.40
Θ_{HMS} (Deg)	22.30	22.00	15.40
Q^2 $(GeV/c)^2$	5.17	6.26	2.20
Total Hours (h)	~40 (~44 runs)	~155 (~135 runs)	~12 (~15 runs)
Elastic Events	~113	~1200	-

Data Analysis

Electrons in HMS



$\vec{e}^{-}\ \vec{p} \longrightarrow e^{-}\ p$

By knowing,

the incoming beam energy, E,

scattered electron energy, E'

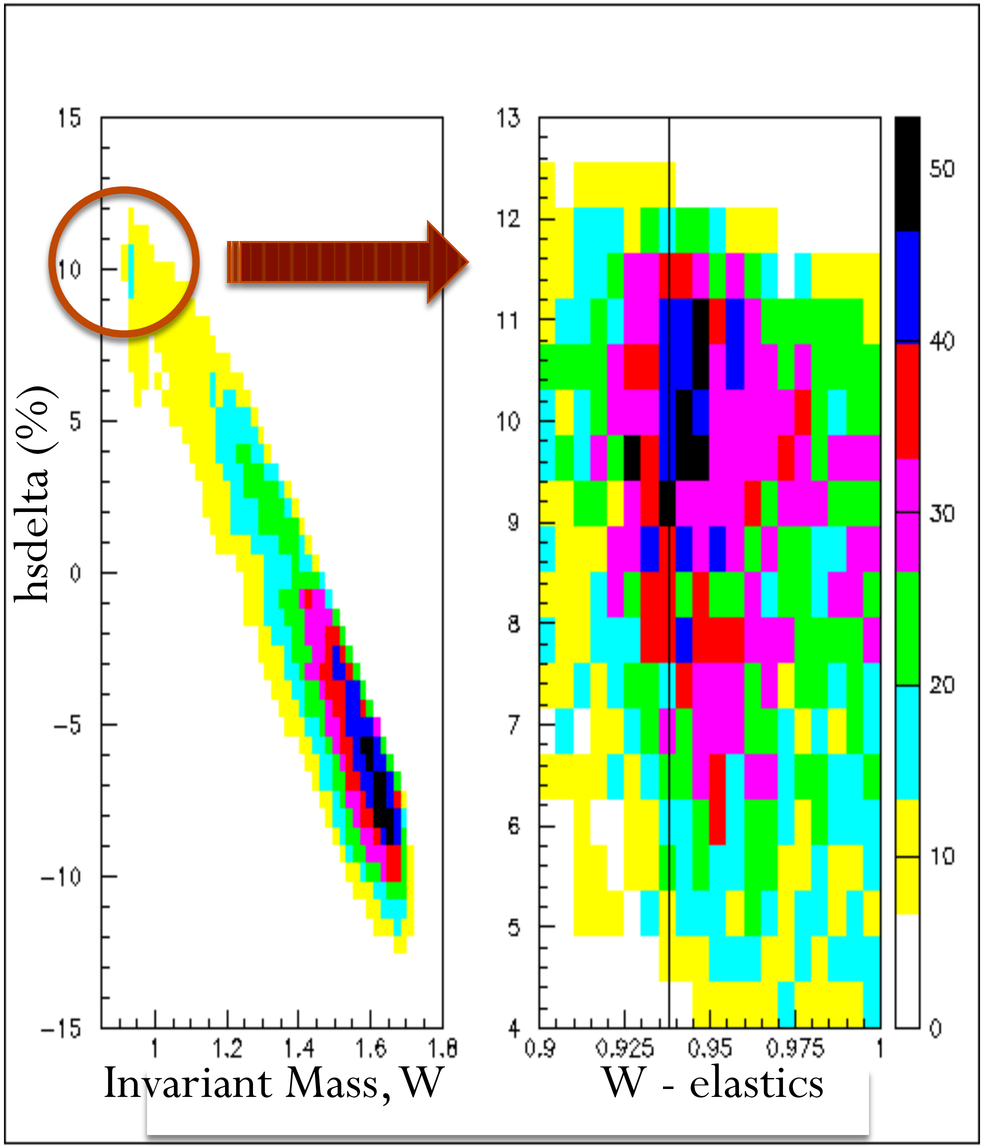
and

the scattered electron angle, θ

$$Q^2 = 4EE'\sin^2\left(\frac{\theta}{2}\right)$$

$$W^2 = M^2 - Q^2 + 2M(E - E')$$

- Momentum Acceptance



$$hsdelta = \left(P - P_c \middle/ P_c \right) = \frac{\delta p}{p}$$

P -Measured momentum in HMS

P_c-HMS central momentum

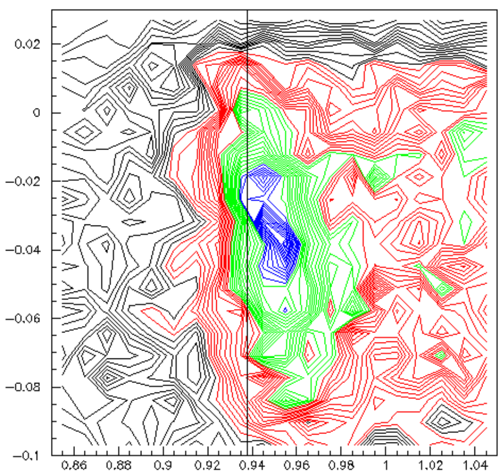
The elastic data are outside of the usual delta cut +/- 8%

Because HMS reconstruction matrix elements work fine up to 10

Use -8% < hsdelta <10%

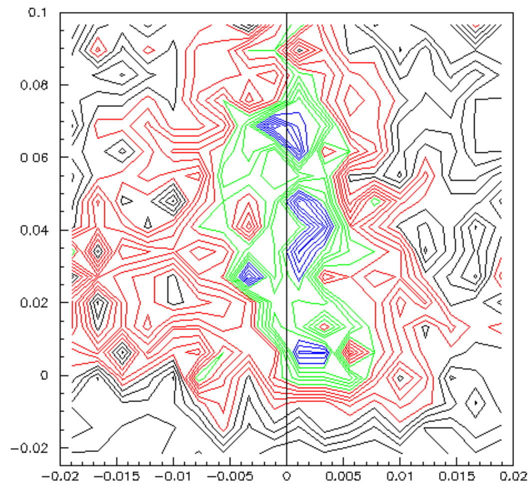
Perp. target magnetic field make some correlations….

In Single Arm electron data



Xptar vs W

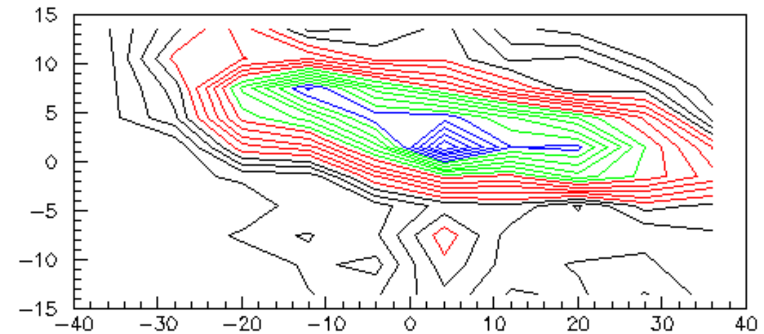
In COIN HMS data



Xptar vs dpel_hms

- Introduced an 'azimuthal angle correction' which correct the target magnetic field in vertical direction in terms of the azimuthal angle. (First make the same correlations on MC/SIMC by applying the correction only for the forward direction and then use the correction on data)
- Different corrections for different detector angles.

In COIN BETA data



Y_HMS-y_clust vs y_clust

Extract the electrons

- Used only Electron selection cuts.

$$\#\text{ of Cerenkov photoelectrons} > 2$$ - Cerenkov cut

$$E_{sh}/E' > 0.7$$ - Calorimeter cut

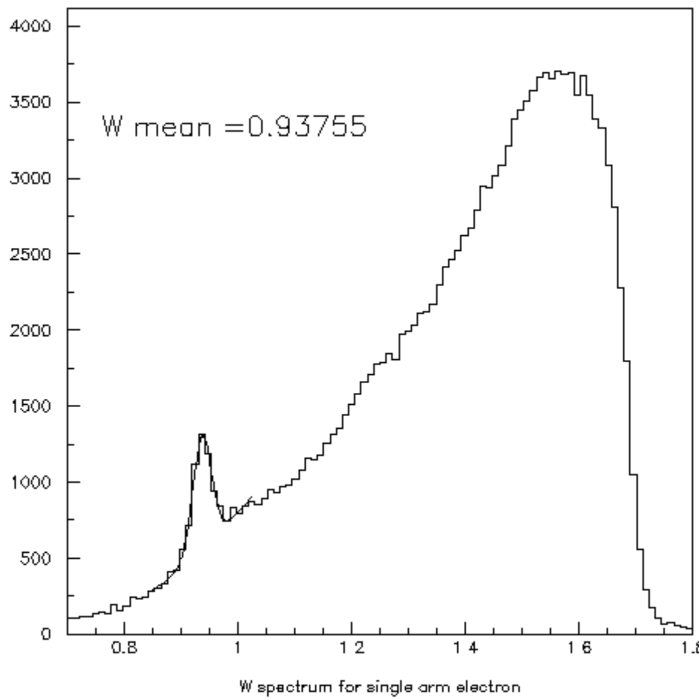
$$\left(P - P_c / P_c\right) < 10 \text{ and } \left(P - P_c / P_c\right) > -8$$ - HMS Momentum Acceptance cut

Here,

P/E' - Detected electron momentum/ energy at HMS

P_c - Central momentum of HMS

E_{sh} - Total measured shower energy of a chosen electron track by HMS Calorimeter



Extracted the Asymmetries …..

The raw asymmetry, A_r

$$A_r = \frac{N^+ - N^-}{N^+ + N^-}$$

$$\Delta A_r = \frac{2\sqrt{N^+}\sqrt{N^-}}{(N^+ + N^-)\sqrt{(N^+ + N^-)}}$$

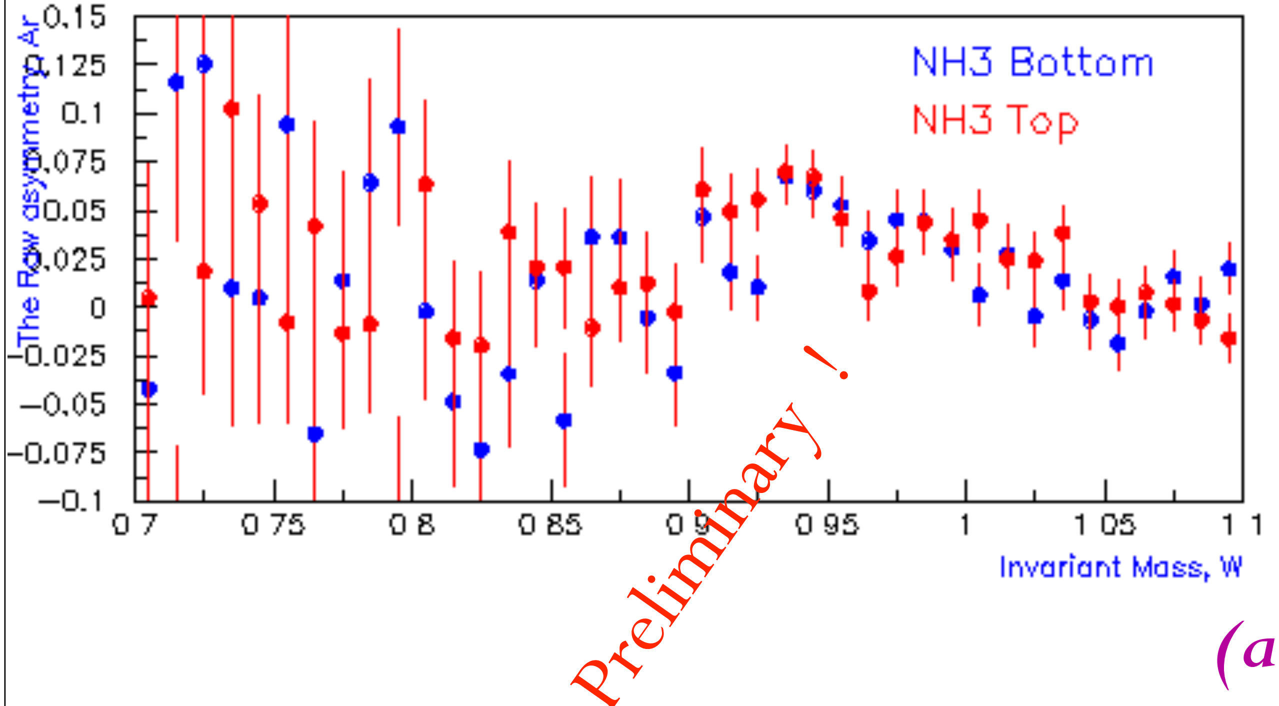
N^+ / N^- = *Charge and life time normalized counts for the +/- helicities*

ΔA_r = *Error on the raw asymmetry*

$P_B P_T$ = *Beam and Target polarization*

N_c = *A correction term to eliminates the contribution from quasi-elastic* ^{15}N *scattering under the elastic peak*

The Asymmetries



Need dilution factor, f

in order to determine the

physics asymmetry,

$$A_p = \frac{A_r}{f P_B P_T} + N_C$$

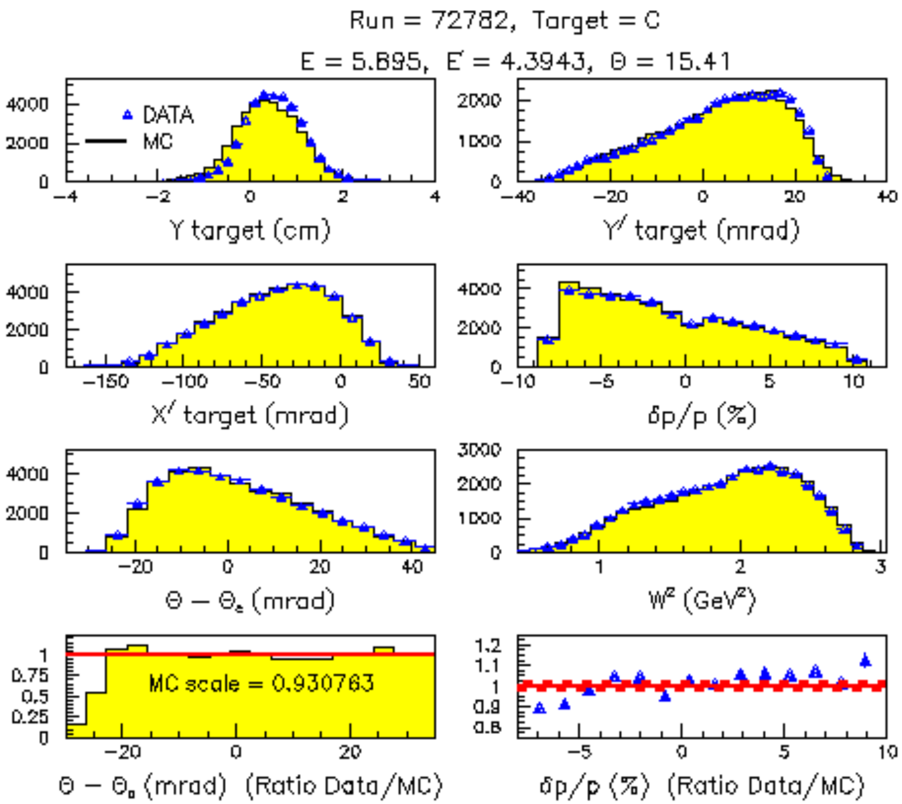
and G^p_E / G^p_M

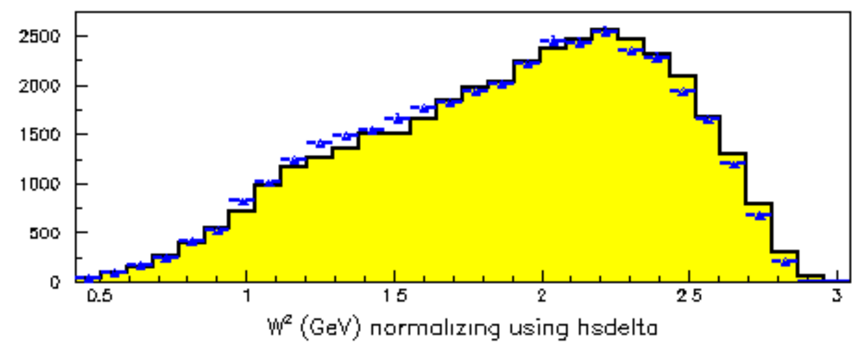
(at Q^2=2.2 (GeV/c)^2)

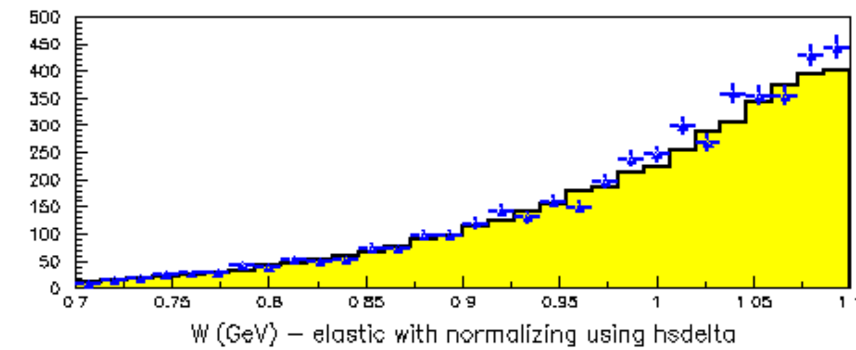
MC for C run

Srast x offset=-0.4 cm

Srast y offset=0.1 cm

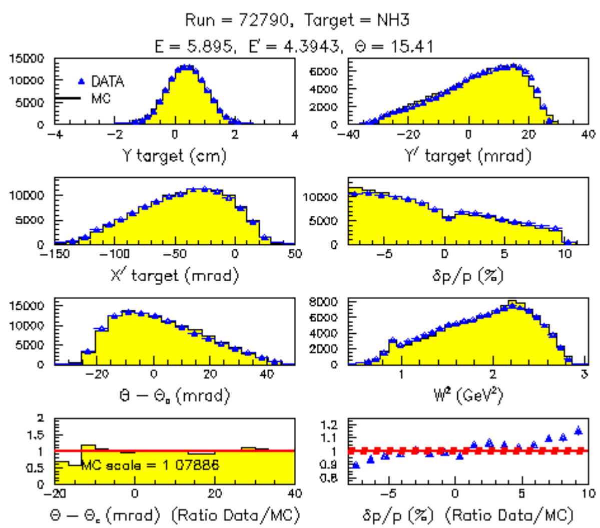


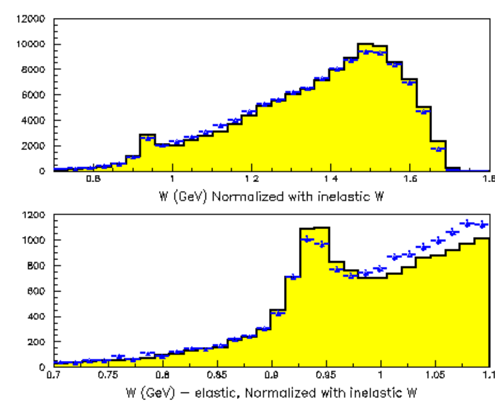




MC with NH3

- Generated N, H and He separately.
- Added Al come from target end caps and 4K shields as well.
- Calculated the MC scale factor using the data/MC luminosity ratio for each target type.
- Added all targets together by weighting the above MC scale factors.
- Used 60% packing fraction.
- Adjust acceptance edges in Ytar and yptar from adjusting the horizontal beam position.
- Adjust the vertical beam position to bring the W peak to 0.938 GeV



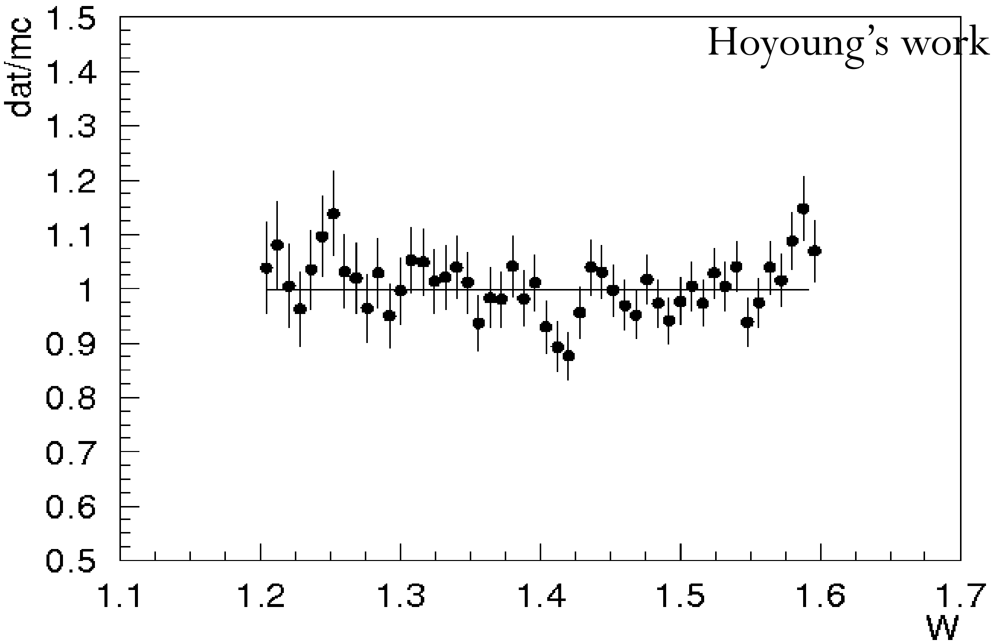


$srast_x = -0.40$ cm

$srast_y = 0.10$ cm

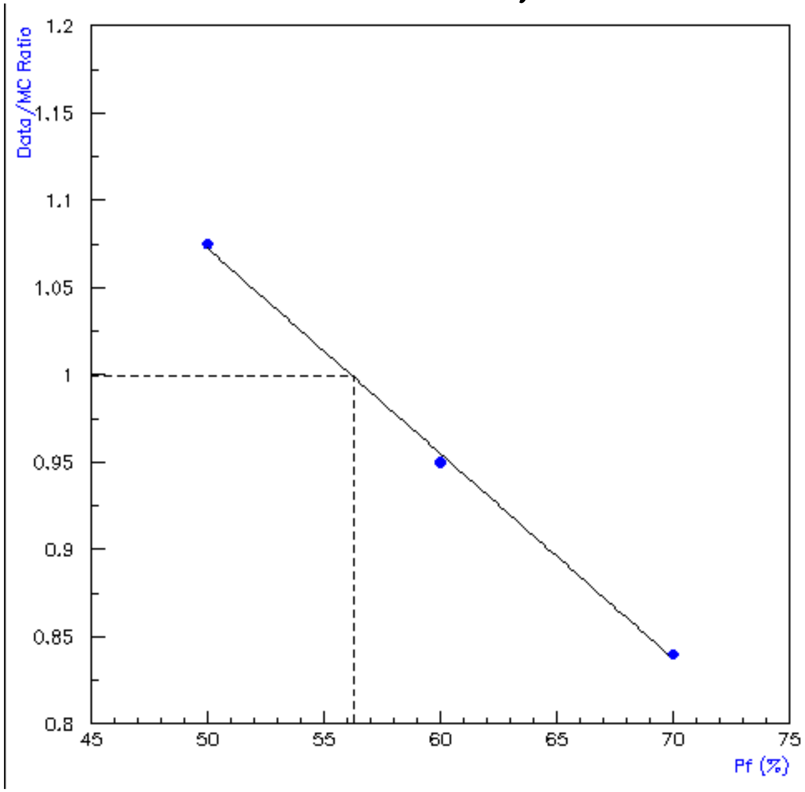
Packing Fraction.

- Packing Fraction is the actual amount of target material used.
- Determined by taking the ratio of data to MC as a function of W.
- Need to determine the packing fractions for each of the NH3 loads used during the data taking.



Determine the Packing Fraction

- Looked data to SIMC comparison for the NH3 target for 3 different Packing Fractions.
- Normalized MC_NH3 by 0.93 which is the factor that brings C data/MC ratio to 1.



- Determined the packing fraction which brings Data/MC ratio to 1 from the plot.
- Packing Fraction=56.3 %

Pf (%)	50	60	70
Data/MC Ratio	1.00	0.88	0.78
Data/MC Ratio/0.93	1.075	0.95	0.84

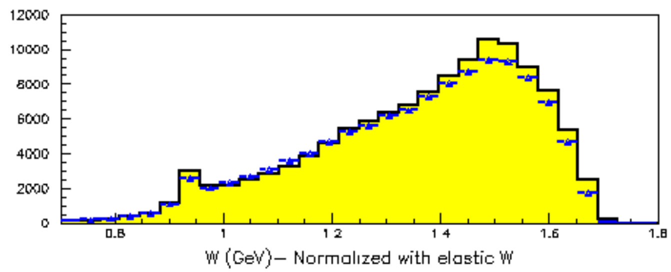
Determination of the Dilution Factor

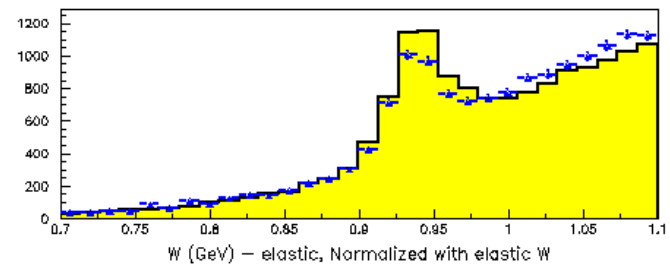
What is the Dilution Factor ?

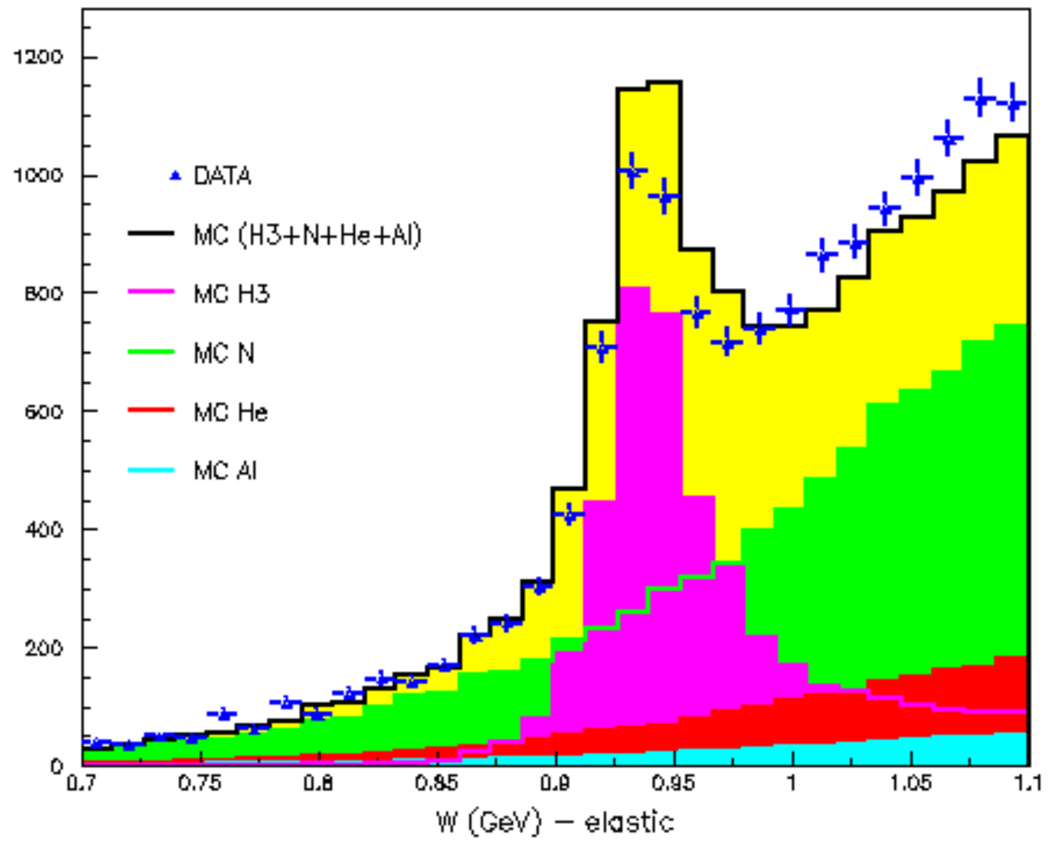
The dilution factor is the ratio of the yield from scattering off free protons(protons from H in NH_3) to that from the entire target (protons from N, H, He and Al)

Dilution Factor,

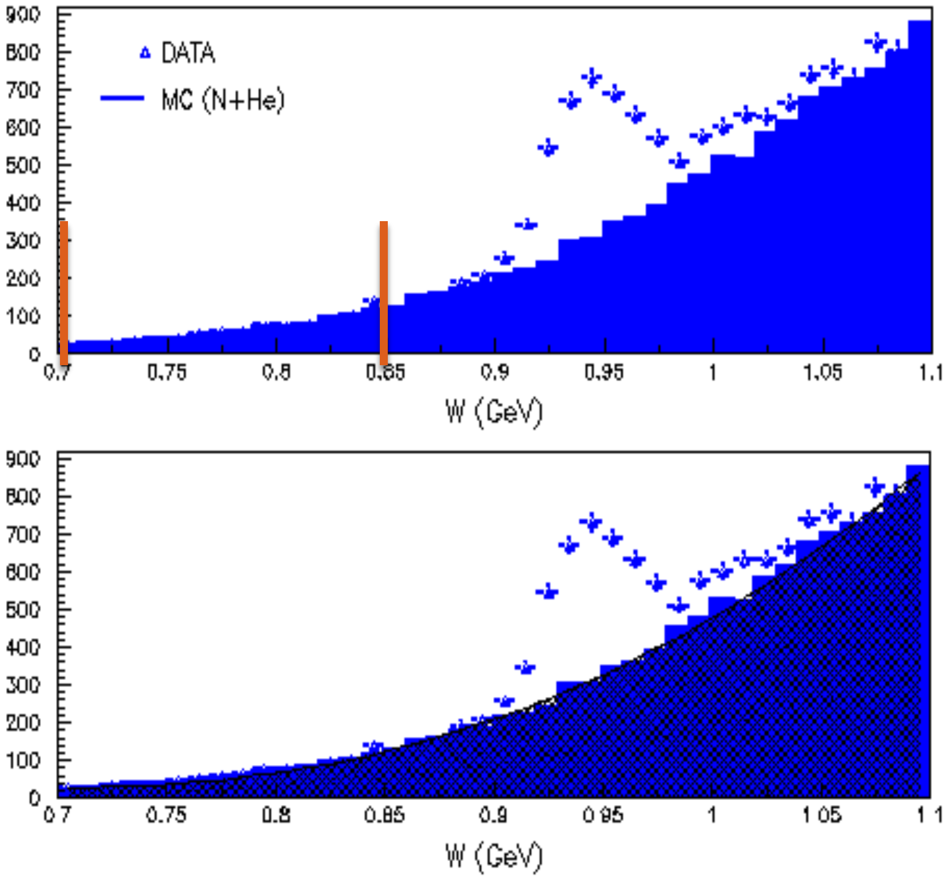
$$F = \frac{Yield_{Data} - Yield_{MC(N+He)}}{Yield_{Data}}$$







- MC Background contributions (Only He+N+Al)



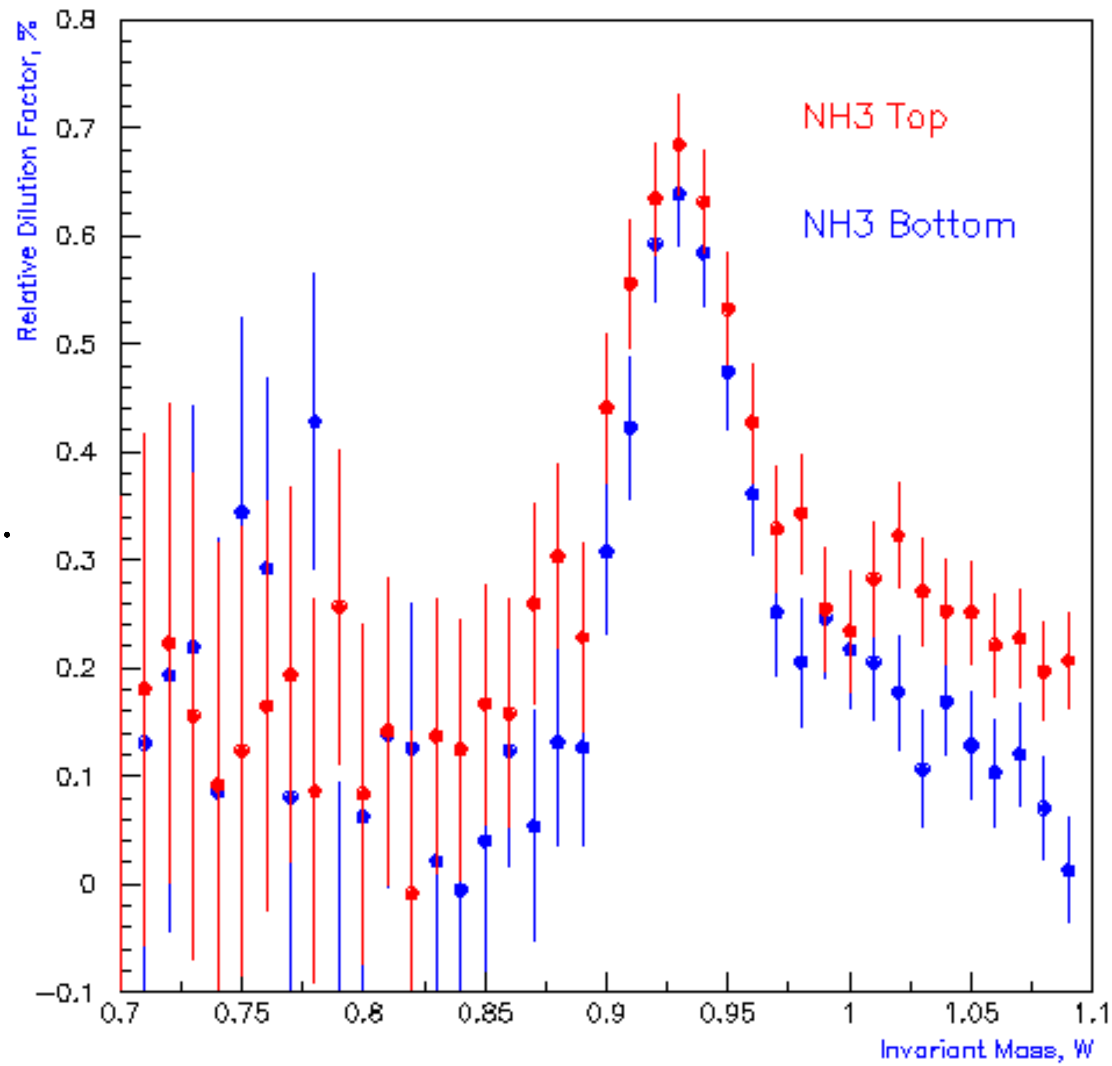
- Calculate the ratio of $Yield_{Data}/Yield_{MC}$ for the W region $0.7 < W < 0.85$ and MC is normalized with this new scaling factor.
- Used the polynomial fit to N+ He+Al in MC and
- Subtract the fit function from data

The relative Dilution Factor **(Preliminary)**

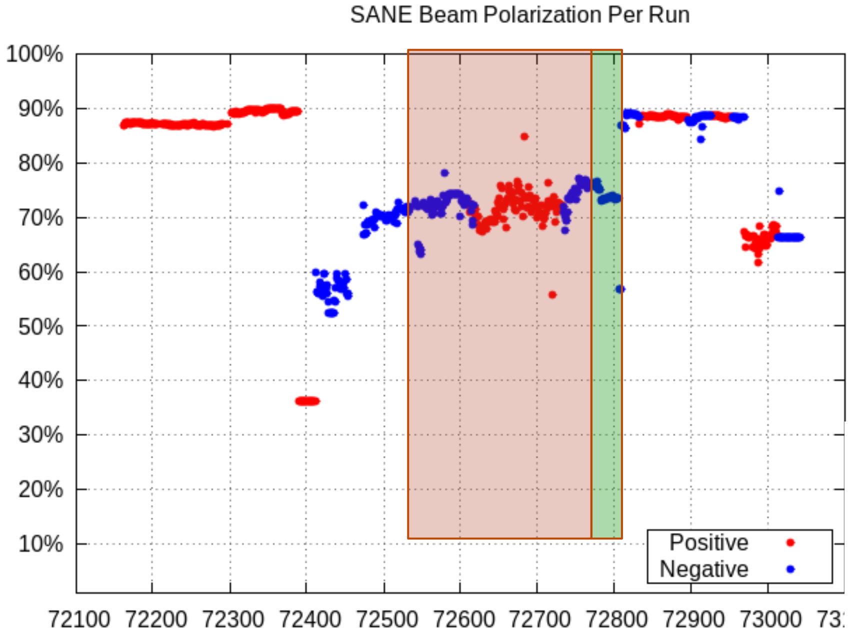
Dilution Factor,

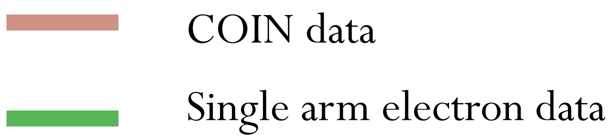
$$F = \frac{Yield_{Data} - Yield_{MC(N+He)}}{Yield_{Data}}$$

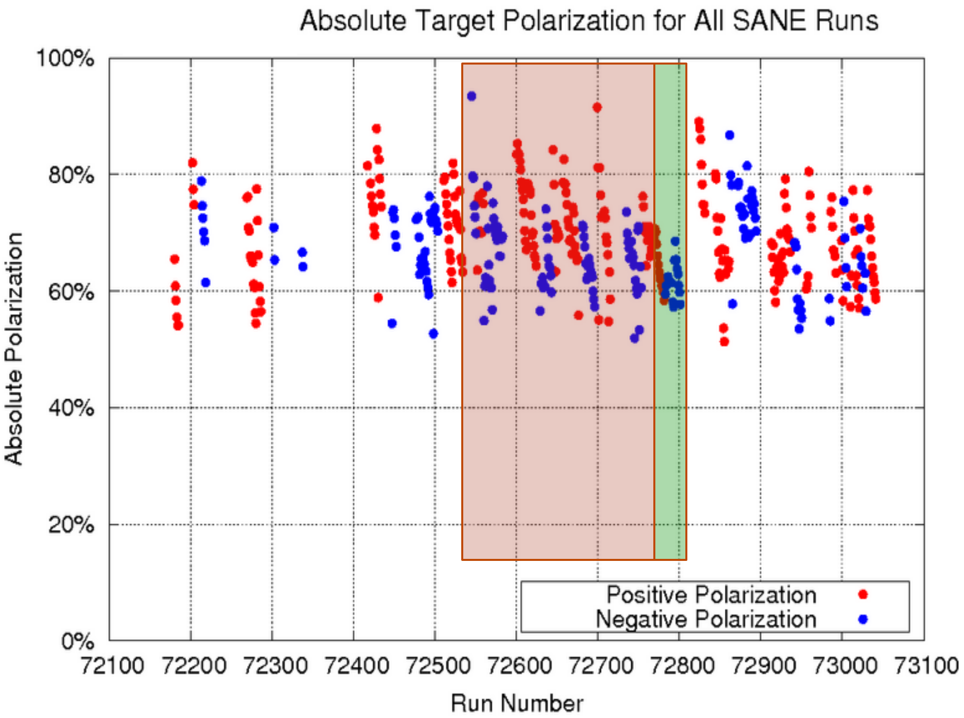
- We have taken data using both NH3 targets, called NH3 top and NH3 bottom.
- NH3 crystals are not uniformly filled in each targets which arise two different packing fractions and hence two different dilution factors.



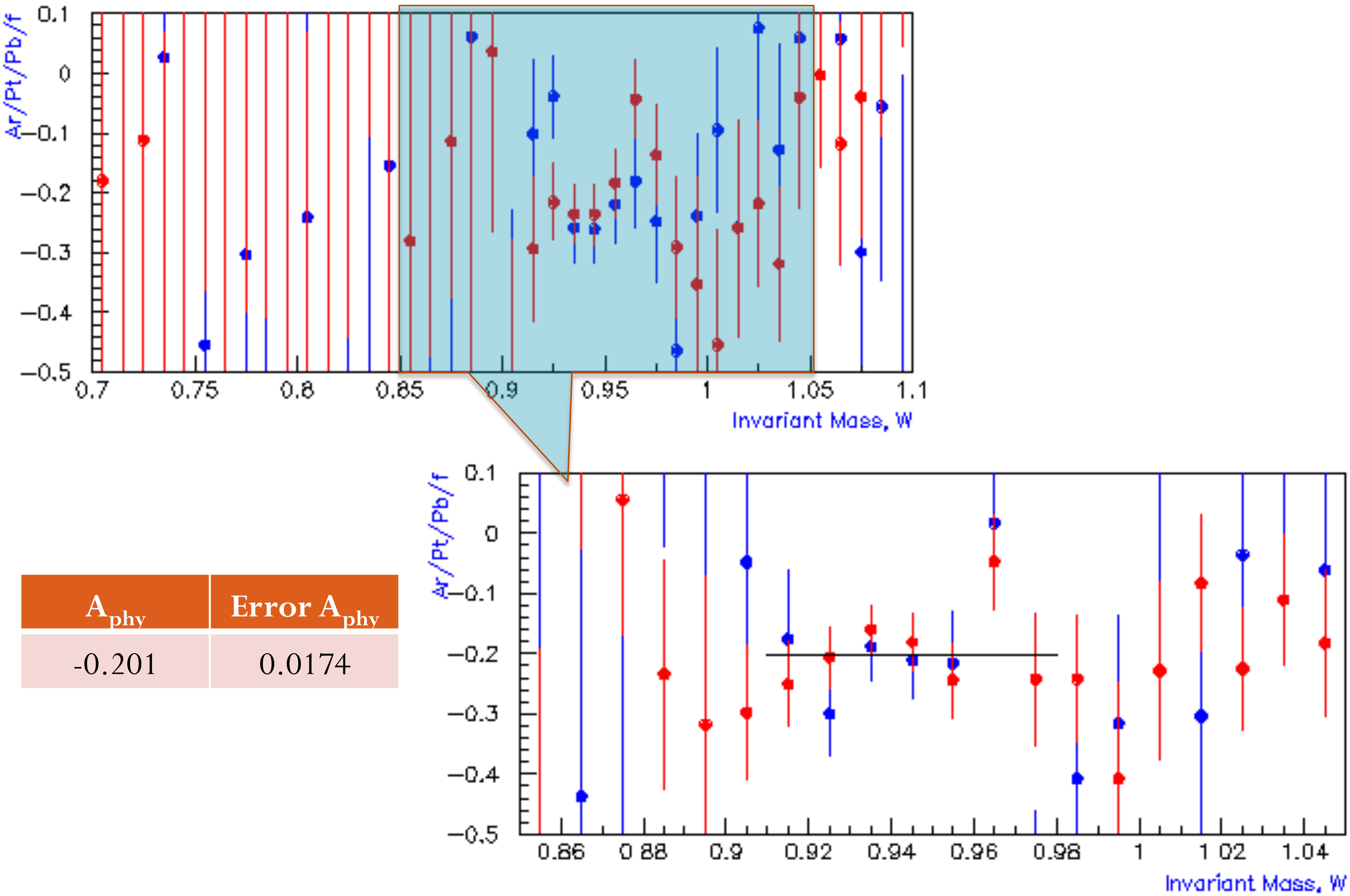
Beam / Target Polarizations







- The Physics Asymmetry **(Preliminary)**



A_{phy}	Error A_{phy}
-0.201	0.0174

- The beam - target asymmetry, A_p

$$A_P = \frac{-br\sin\theta^*\cos\phi^* - a\cos\theta^*}{r^2 + c}$$

$$\frac{G_E}{G_M} = -\frac{b}{2A_p}\sin\theta^*\cos\phi^* + \sqrt{\frac{b^2}{4A_p^2}\sin^2\theta^*\cos^2\phi^* - \frac{a}{A_P}\cos\theta^* - c}$$

Using the exeperiment data at

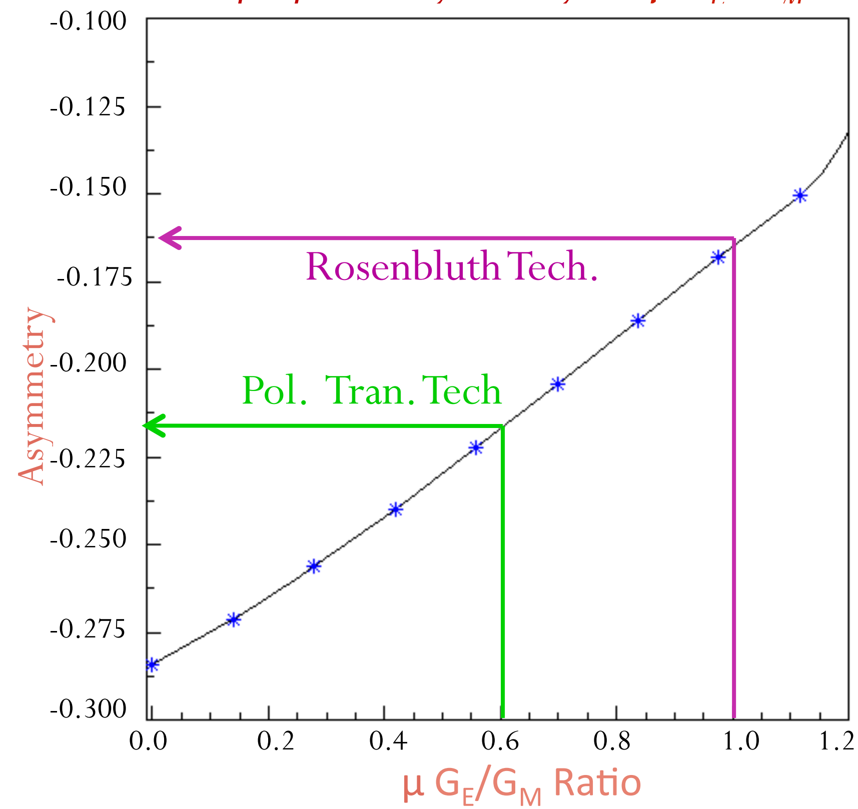
$Q^2 = 2.2\ (\mathrm{GeV}/c)^2$

$\theta^* \approx 34.55°$ *and* $\phi^* = 180°$

From the HMS kinematics, $r^2 << c$

$$A_P = \frac{-b\sin\theta^*\cos\phi^* r}{c} - \frac{a\cos\theta^*}{c}$$

The projected asymmetry vs $\mu G_E/G_M$



Using the exeperiment data at $Q^2=2.2\ (GeV/c)^2$ and by knowing the Ap=-0.201,

$$r=\left(\frac{G_E}{G_M}\right)=0.2416$$

$$\mu r=\mu\left(\frac{G_E}{G_M}\right)=0.674$$

Where , μ – Magnetic Moment of the Proton=2.79

- Error propagation from the experiment

$$A_P=\frac{-b\sin\theta^{*}\cos\phi^{*} r}{c}-\frac{a\cos\theta^{*}}{c}$$

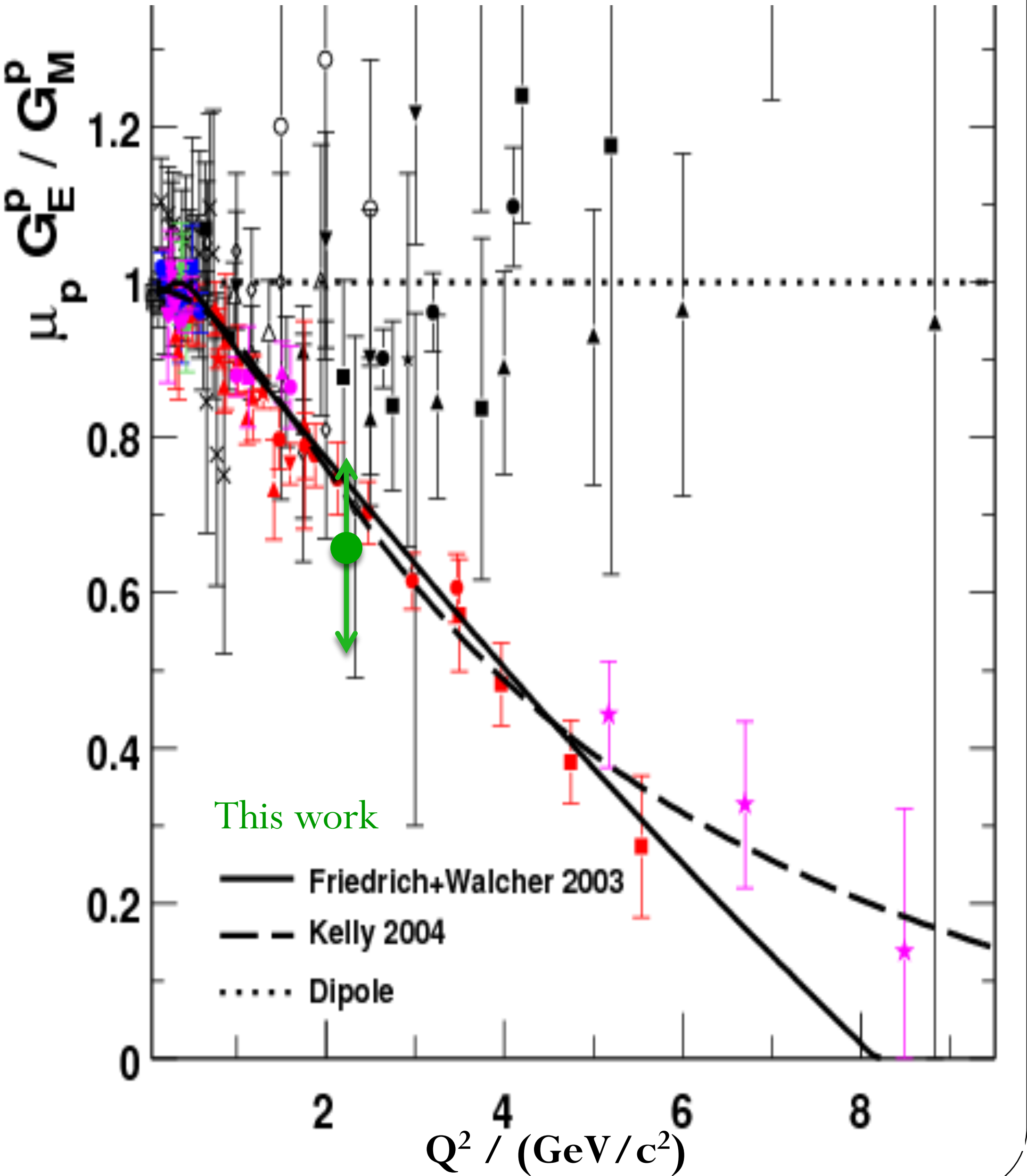
$$\Delta r=\Delta\left(\frac{G_E}{G_M}\right)=\left|\frac{c}{b\sin\theta^{*}\cos\varphi^{*}}\right|\Delta A_p$$

By knowing the Δ Ap=0.017,

$$\Delta(\mu r)=\Delta\left(\mu\frac{G_E}{G_M}\right)=0.13$$

Preliminary …..

$\mu G_E/G_M$	$\Delta(\mu G_E/G_M)$
0.674	0.13



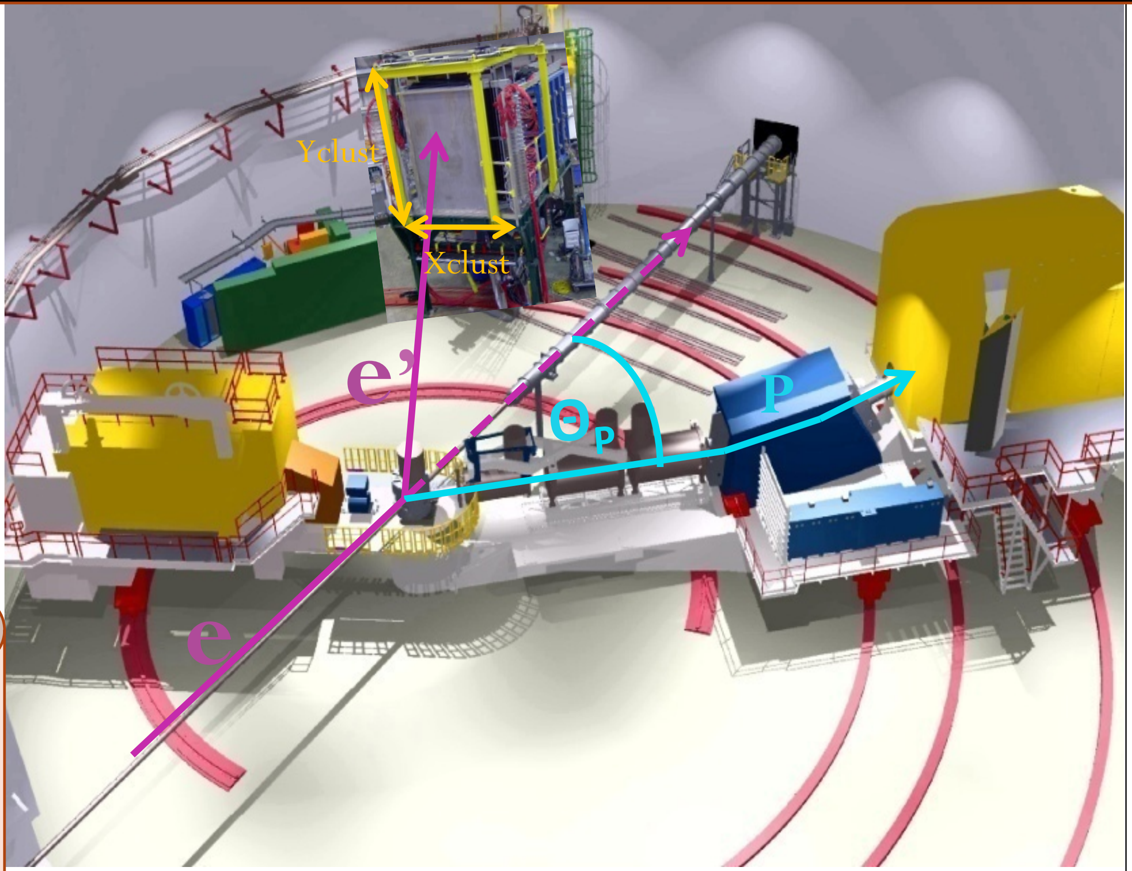
Coincidence Data
(Electrons in BETA and Protons in HMS)

<u>Definitions :</u>

X/Yclust - Measured X/Y positions on the BigCal

- *X = horizontal / in-plane coordinate*
- *Y = vertical / out – of – plane coordinate*

Eclust - Measured electron energy at the BigCal



By knowing
the energy of the polarized electron beam, E_B
and
the scattered proton angle, Θ_P

We can predict the
- X/Y coordinates - X_HMS, Y_HMS and (Target Magnetic Field Corrected)
- The Energy - E_HMS

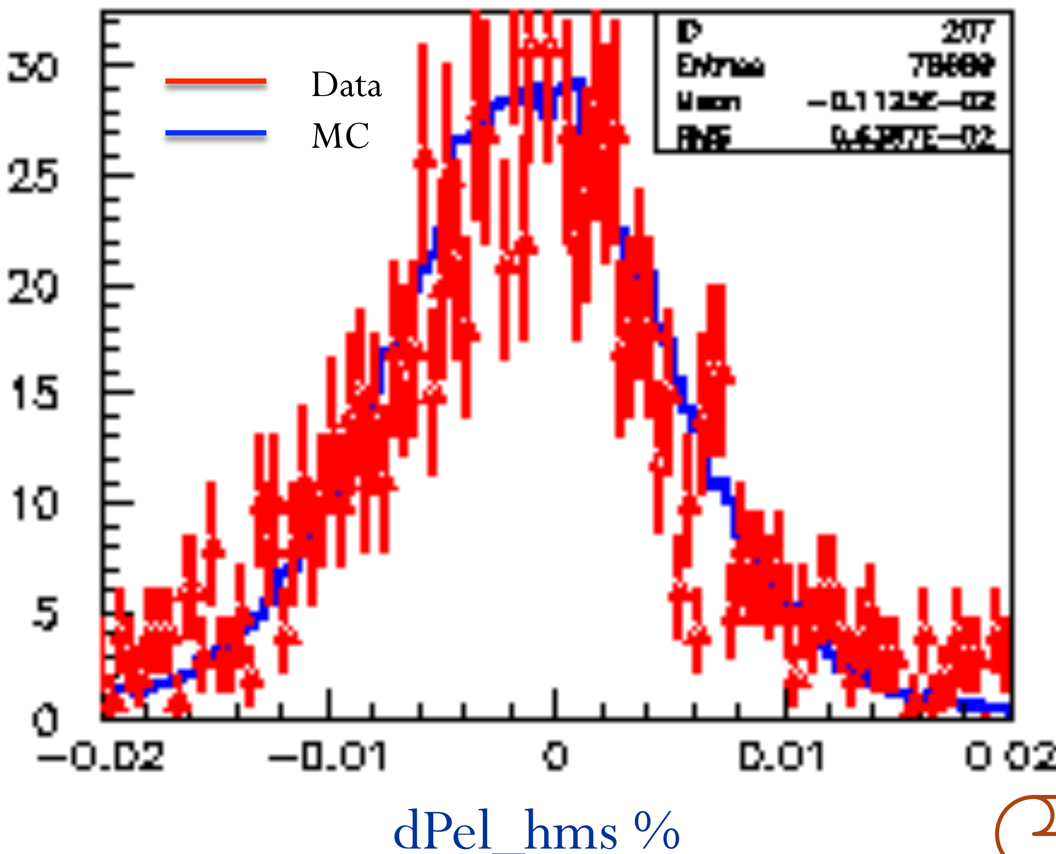
of the coincidence electron on the BigCal

Elastic Kinematics

(From HMS Spectrometer)

Spectrometer mode	Coincidence	Coincidence	Single Arm
HMS Detects	Proton	Proton	Electron
E Beam GeV	4.72	5.89	5.89
P_{HMS} GeV/c	3.58	4.17	4.40
Θ_{HMS} (Deg)	22.30	22.00	15.40
Q^2 $(GeV/c)^2$	5.17	6.26	2.20
Total Hours (h)	~40 (~44 runs)	~155 (~135 runs)	~12 (~15 runs)
e-p Events	~113	~1200	-

Fractional momentum difference



$$dPel\_hms = \frac{P_{HMS} - P_{Cal}}{P_{cent}}$$

$$P_{Cal} = \sqrt{\left(\nu^2 + 2M\nu\right)}$$

$$\nu = \frac{Q^2}{2M}$$

$$Q^2 = \frac{4M^2E^2\cos^2\theta}{M^2 + 2ME + E^2\sin^2\theta}$$

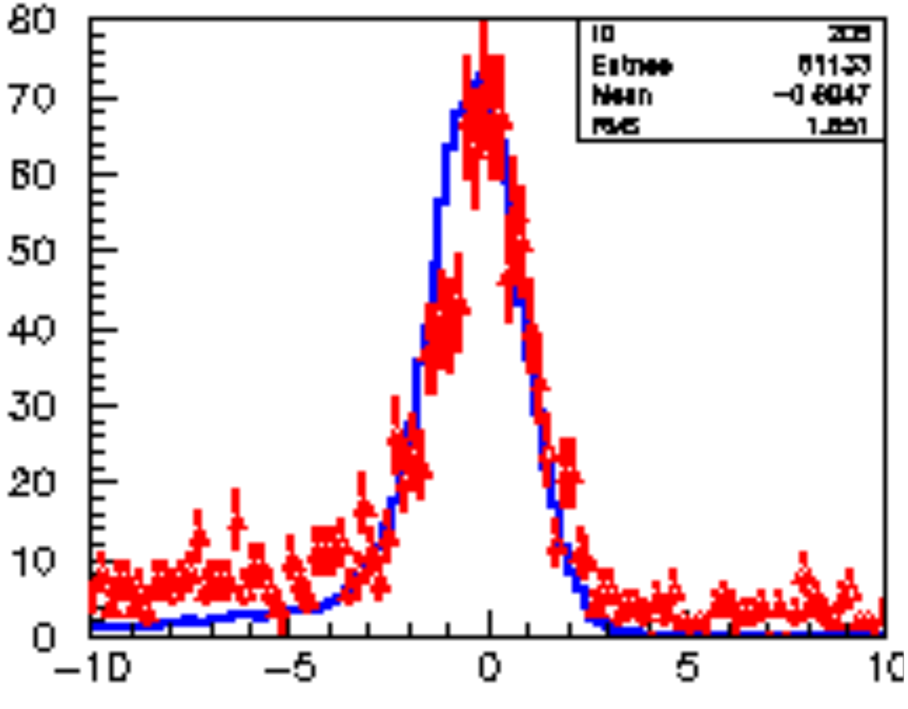
P_{HMS} – *Measured proton momentum by HMS*

P_{cal} - *Calculated proton momentum by knowing the beam energy, E and the proton angle,* Θ

P_{cent} – *HMS central momentum*

X/Y position difference

X position difference

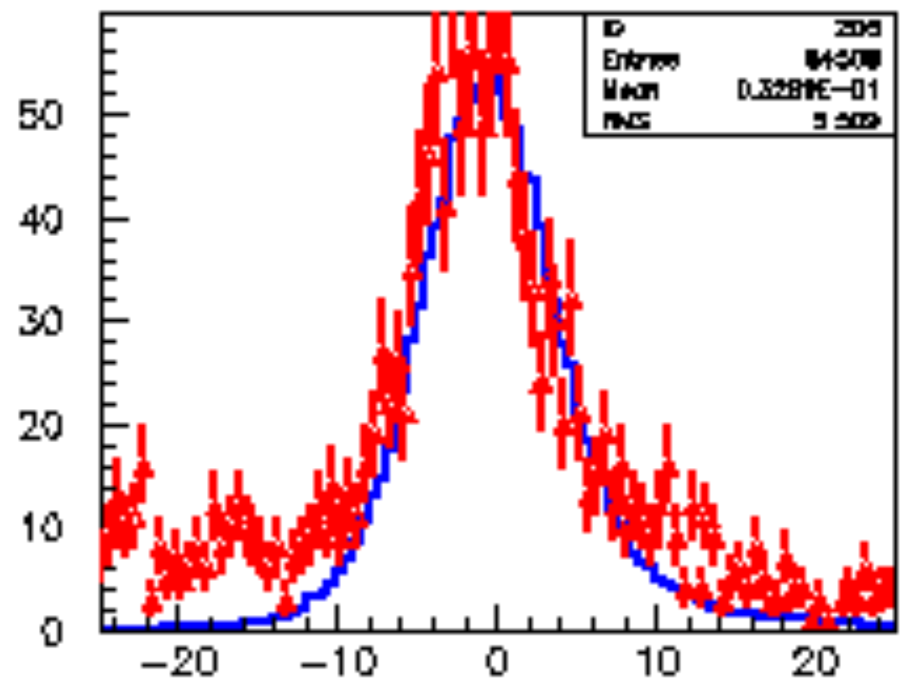


X_HMS-Xclust / cm

Data

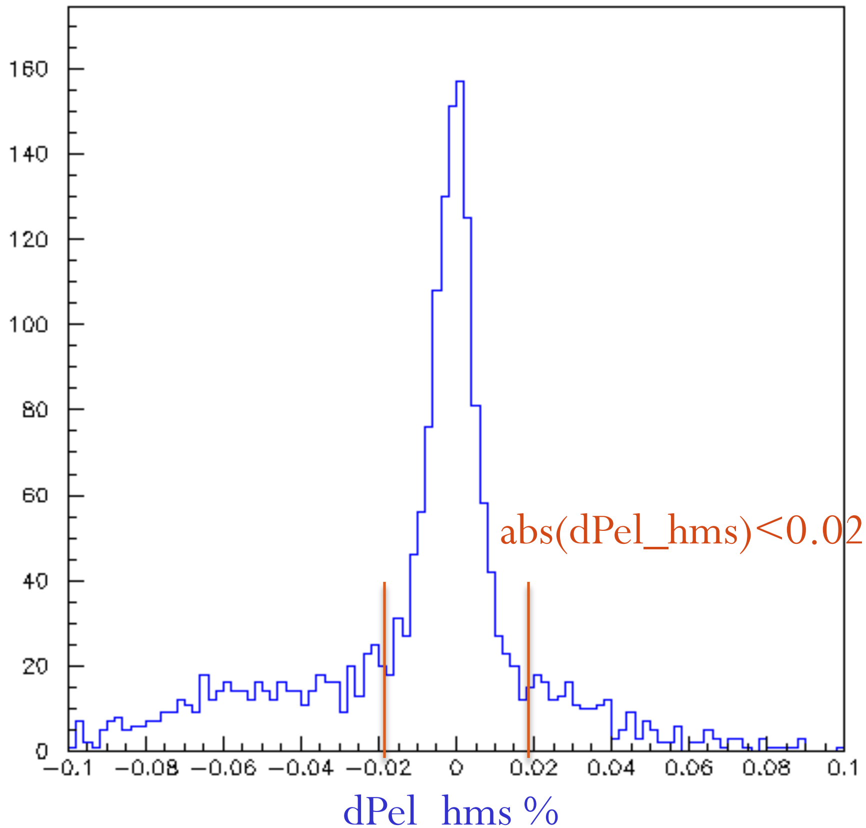
MC

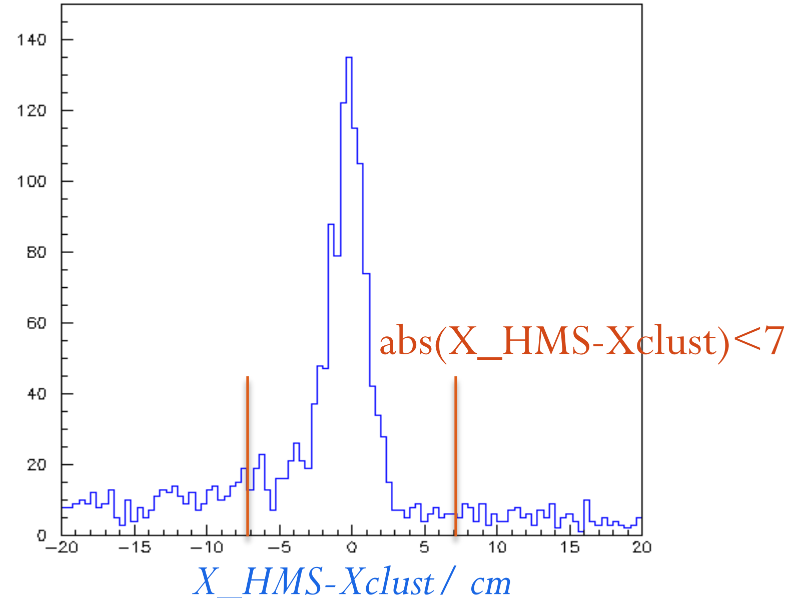
Y position difference

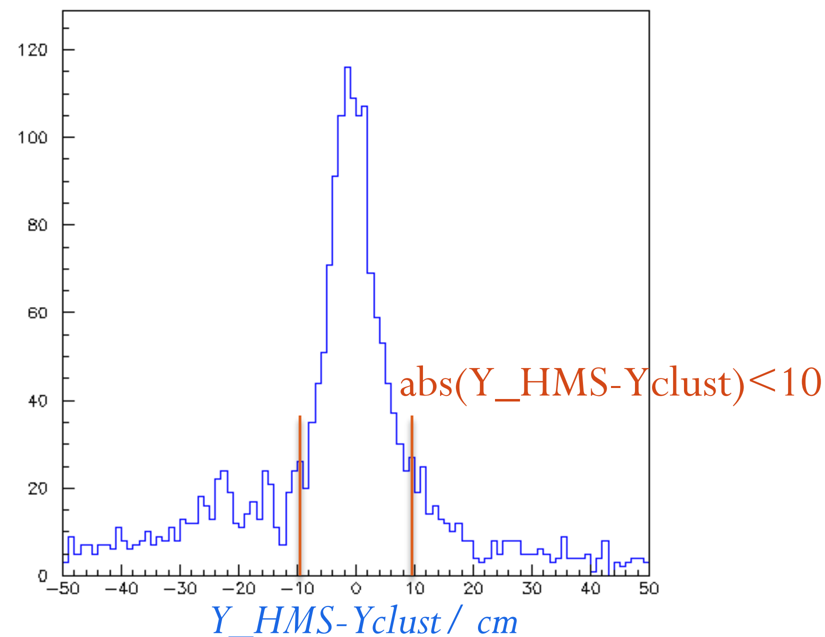


Y_HMS-Yclust / cm

Applied the coincidence cuts

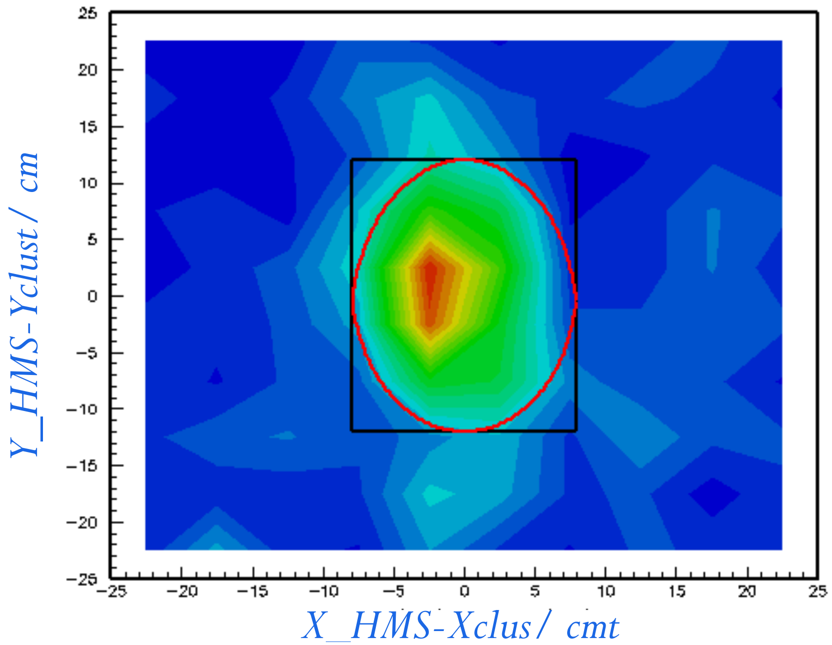




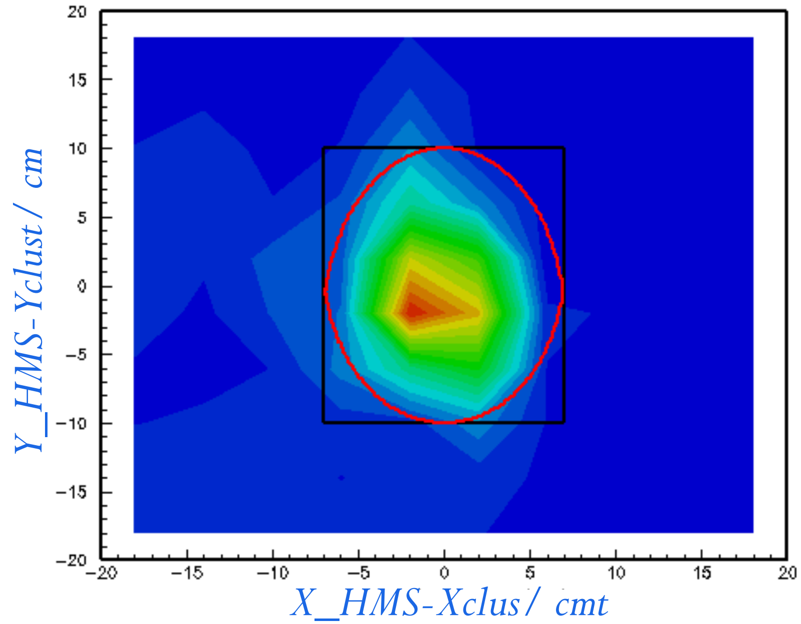


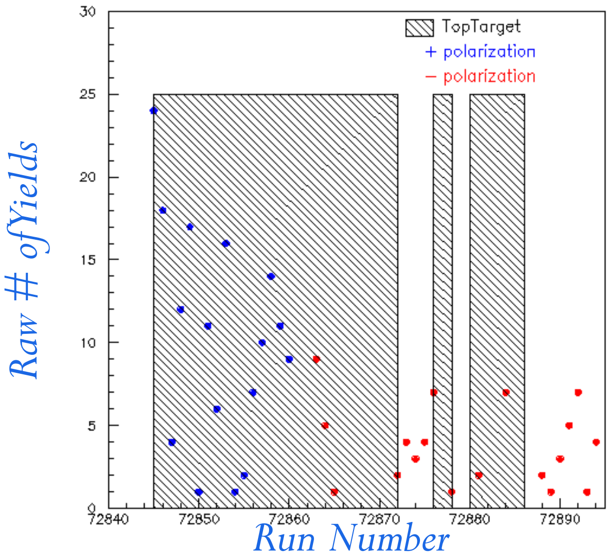
Elastic Events

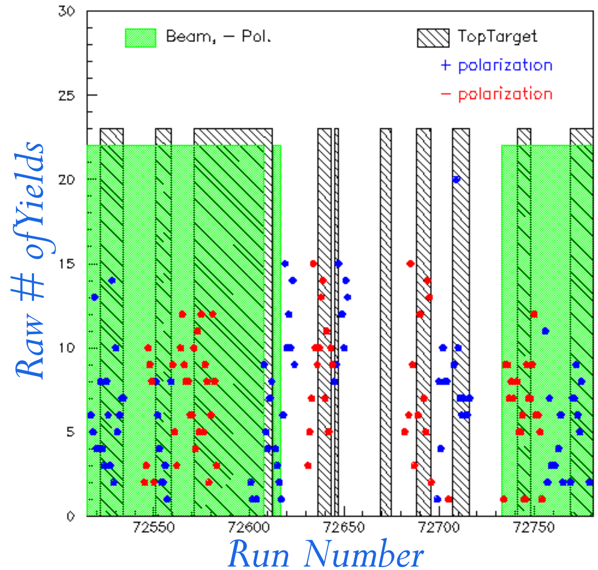
4.72 GeV data



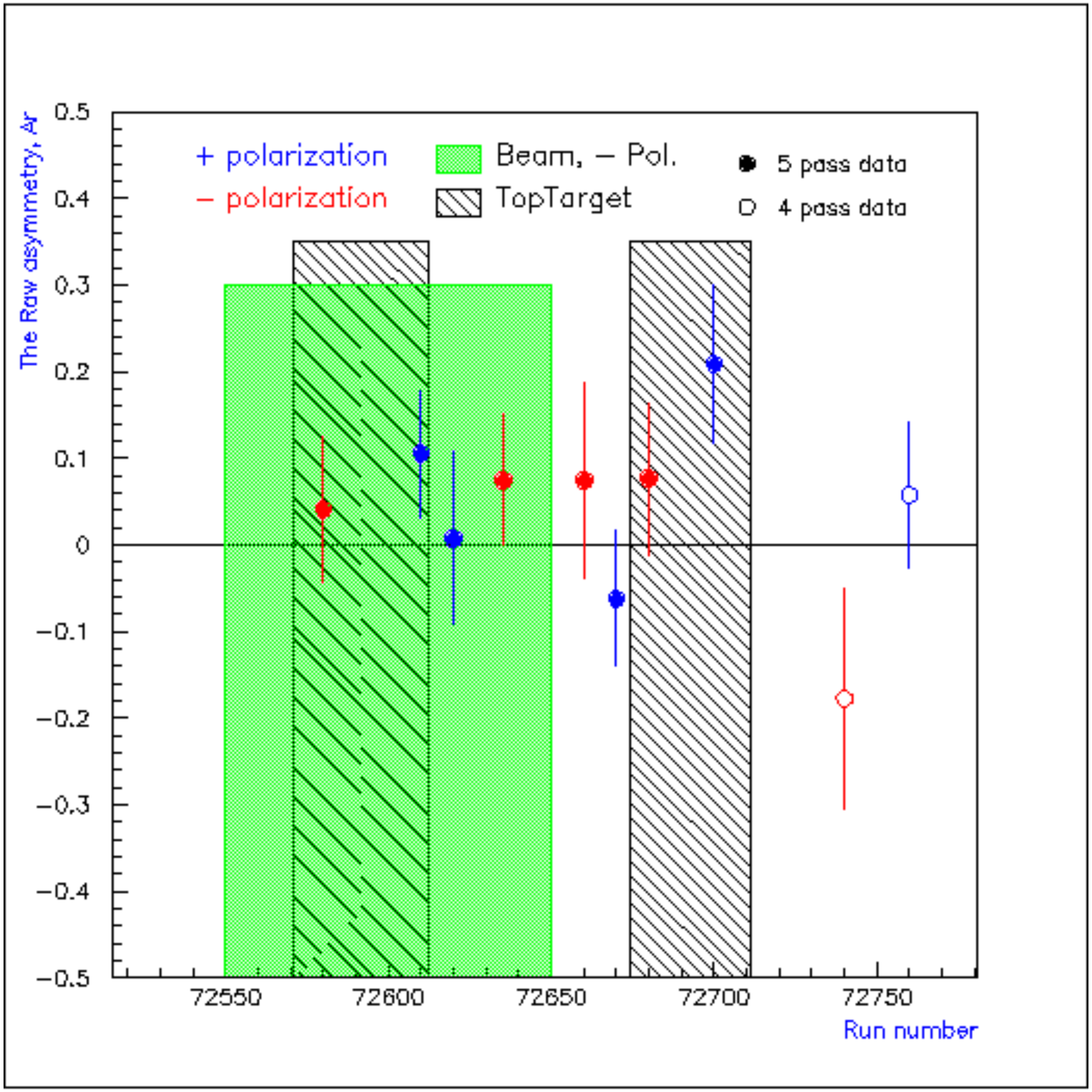
5.89 GeV data







Extract the Raw Asymmetries



Raw yields are normalized with

- Total Charge
- charge average +/- life times

Need

dilution factor, f

in order to determine the

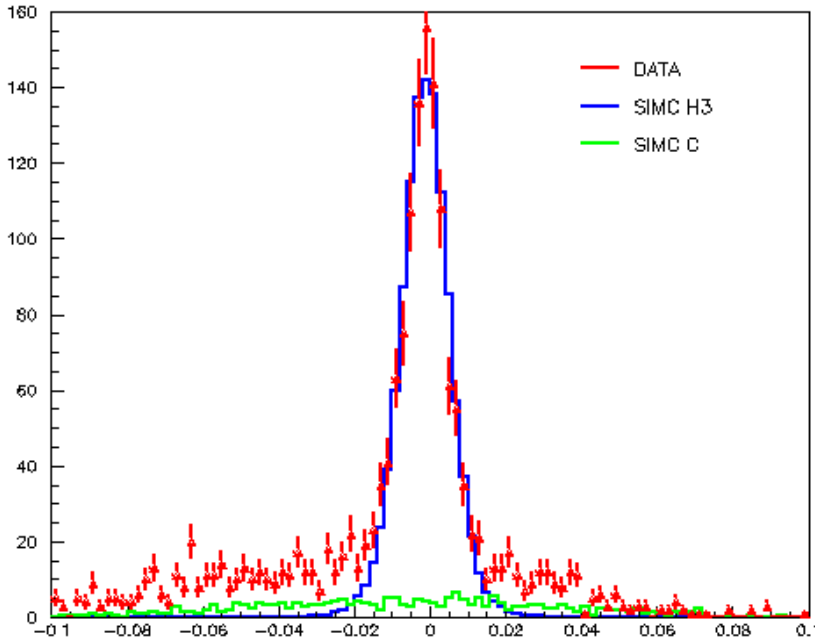
physics asymmetry,

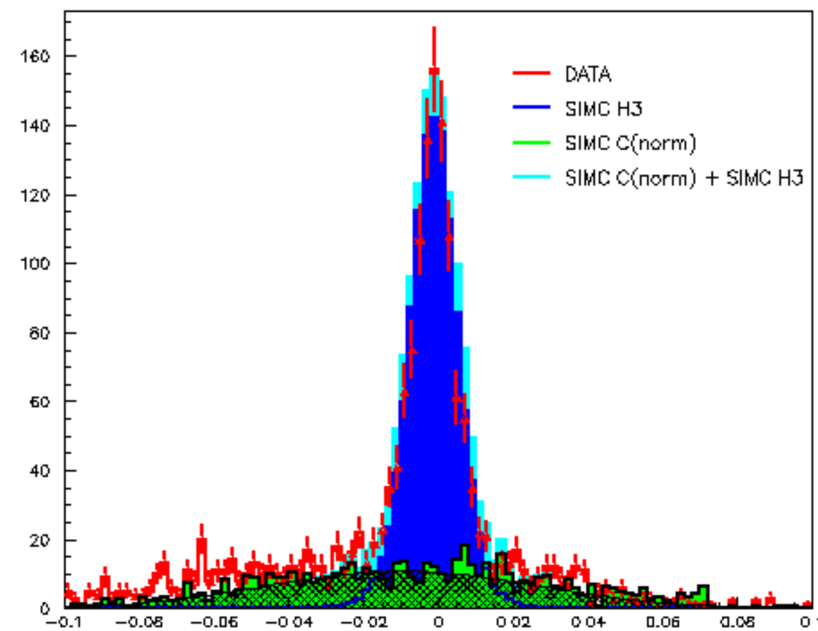
$$A_p = \frac{A_r}{fP_BP_T} + N_C$$

and G^P_E / G^P_M

Determine The Dilution Factor

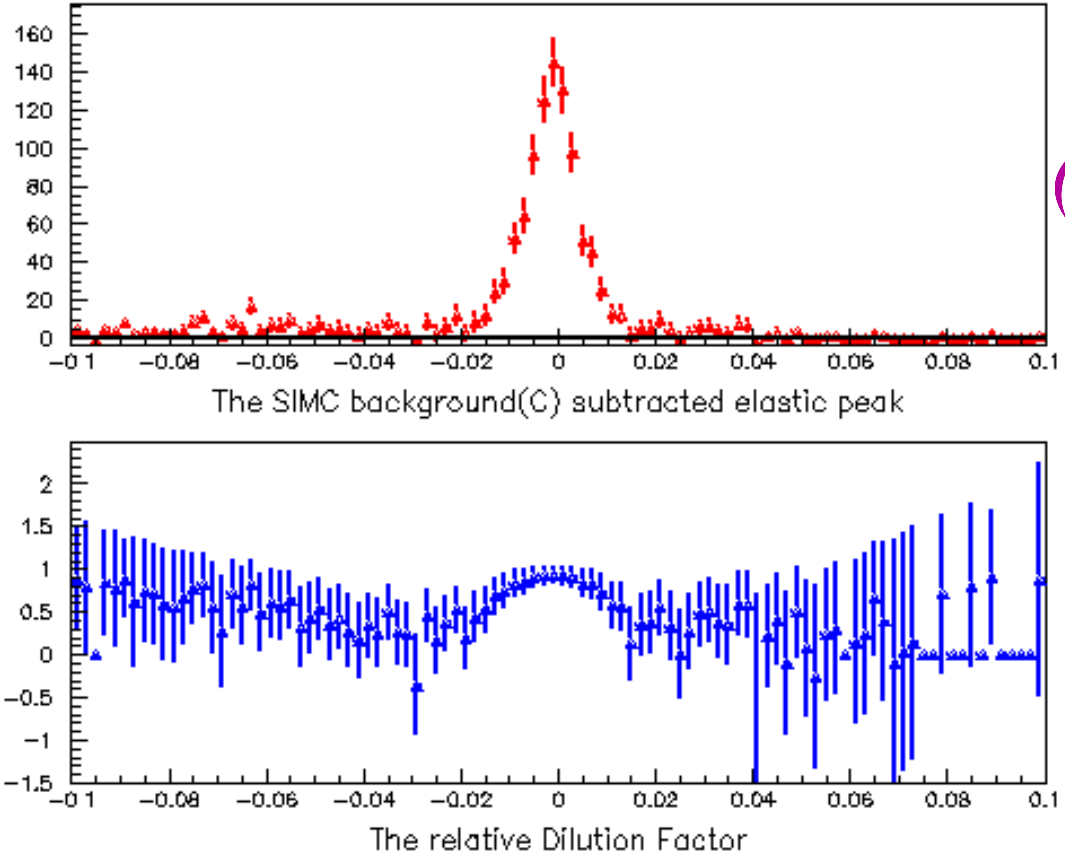
- Estimate The Background





- Get the ratio of data/SIMC_C for the region of 0.03 < dpel_hms < 0.08. (ratio=2.73893)
- Normalized the SIMC_C with that ratio (2.73893) for the region of -0.1 < dpel_hms < 0.1 and added SIMC_H3 to it. Compare with the data.
  Data/SIMC(H3+2.73893*C) = 0.991536
- Used the Gaussian fit for the SIMC_C (normalized with 2.73893) and subtract it from the data
- Get the relative dilution factor by taking the ratio of SIMC_C substracted data to data.
  the relative df. = (data-SIMC_C)/data

- Get The Relative Dilution Factor



Two different target cups (NH$_3$ Top and NH$_3$ Bottom)

↓

Two different packing fractions

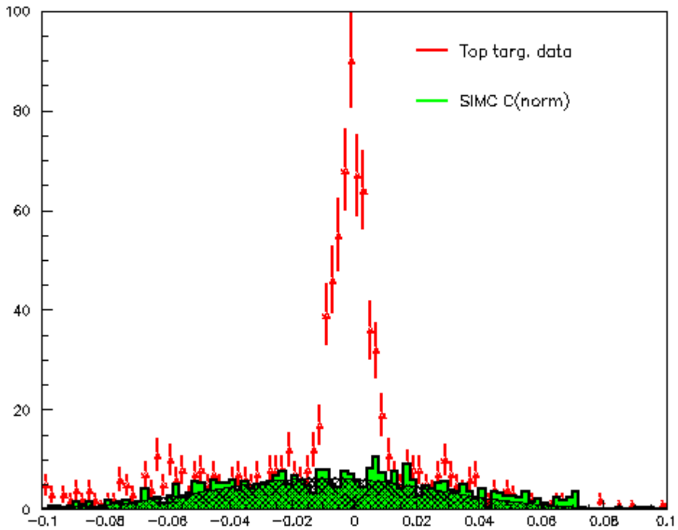
↓

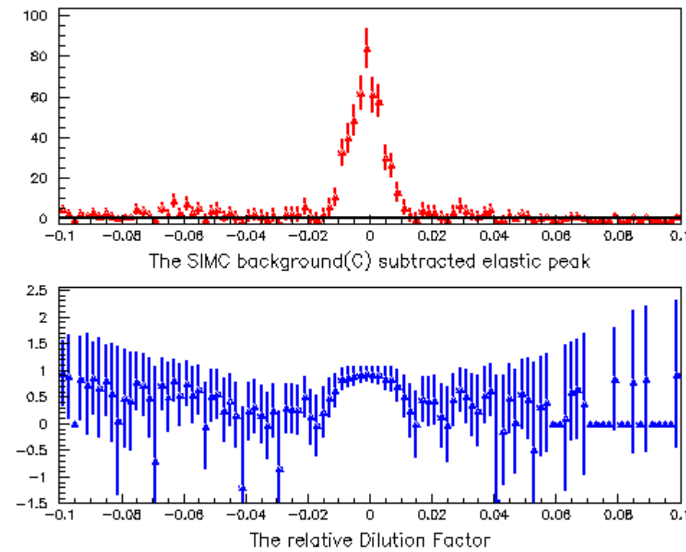
Need

Two different dilution factors

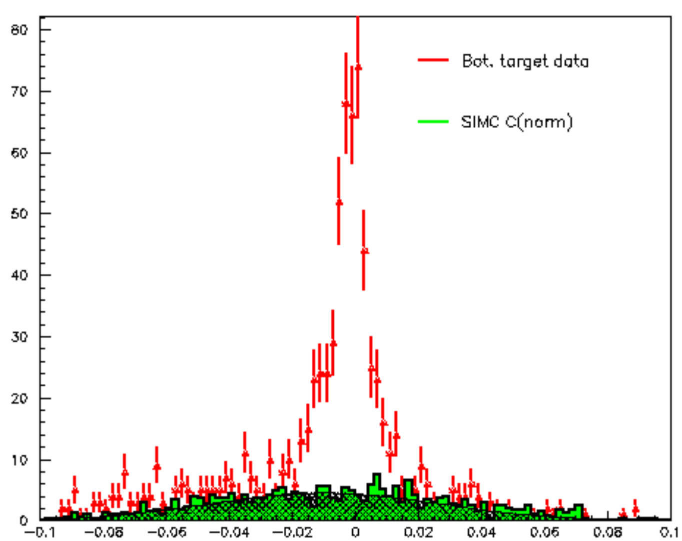
• The Relative Dilution Factors For

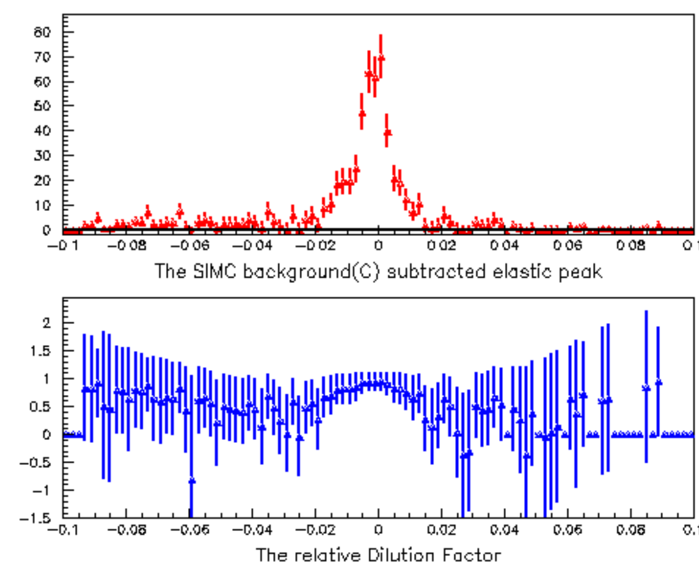
Top Target





Bottom Target

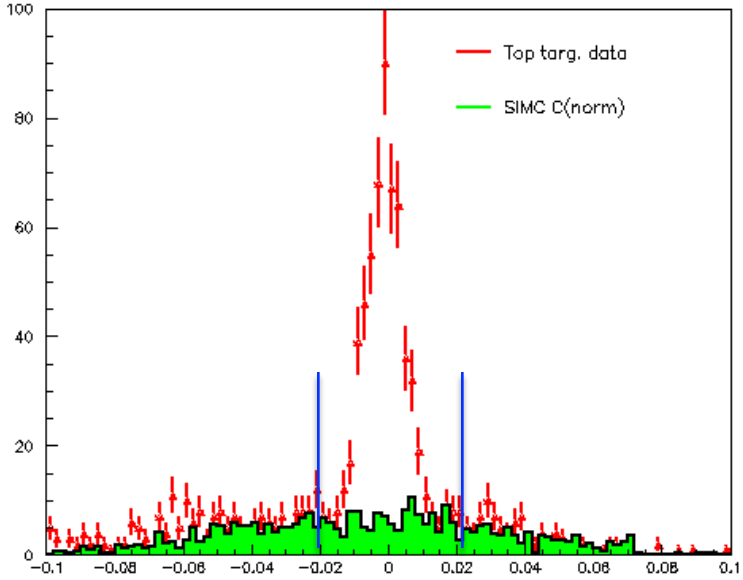




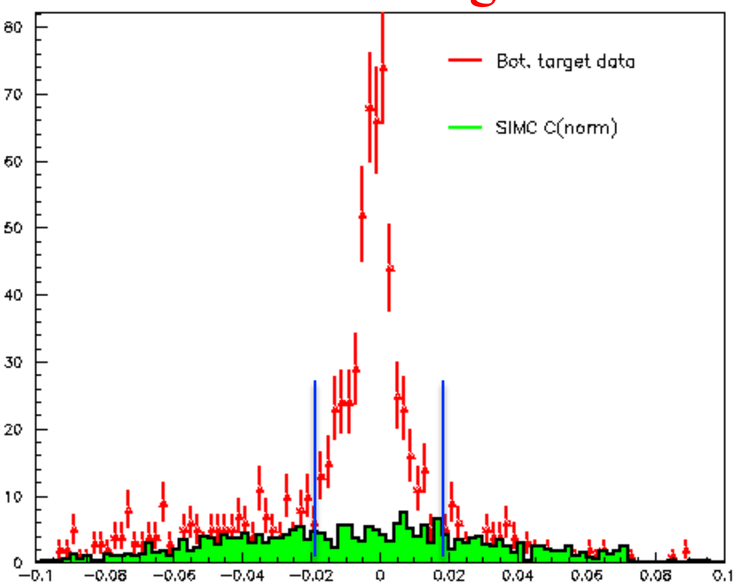
The Relative Dilution Factor (Used the Integration Method)

- Because of the law statistics, It is hard to correct the raw asymmetry for the df as a function of dpel_hms
- Just integrate over the dpel_hms region of +/- 0.02 for the top and bottom.

Top Target



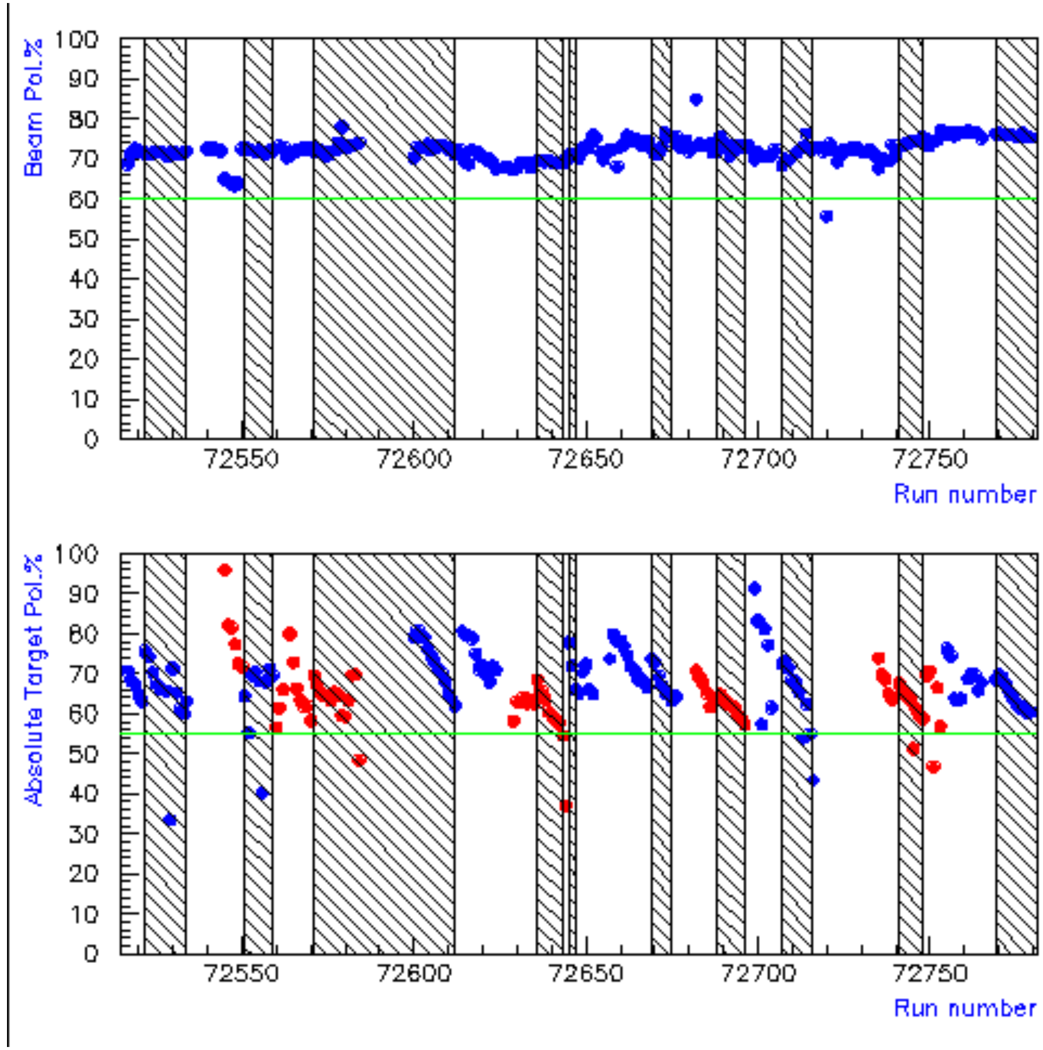
Bottom Target



The relative D.F = (data-SIMC_C)_top/data_top
= 606-130/606
= 0.785

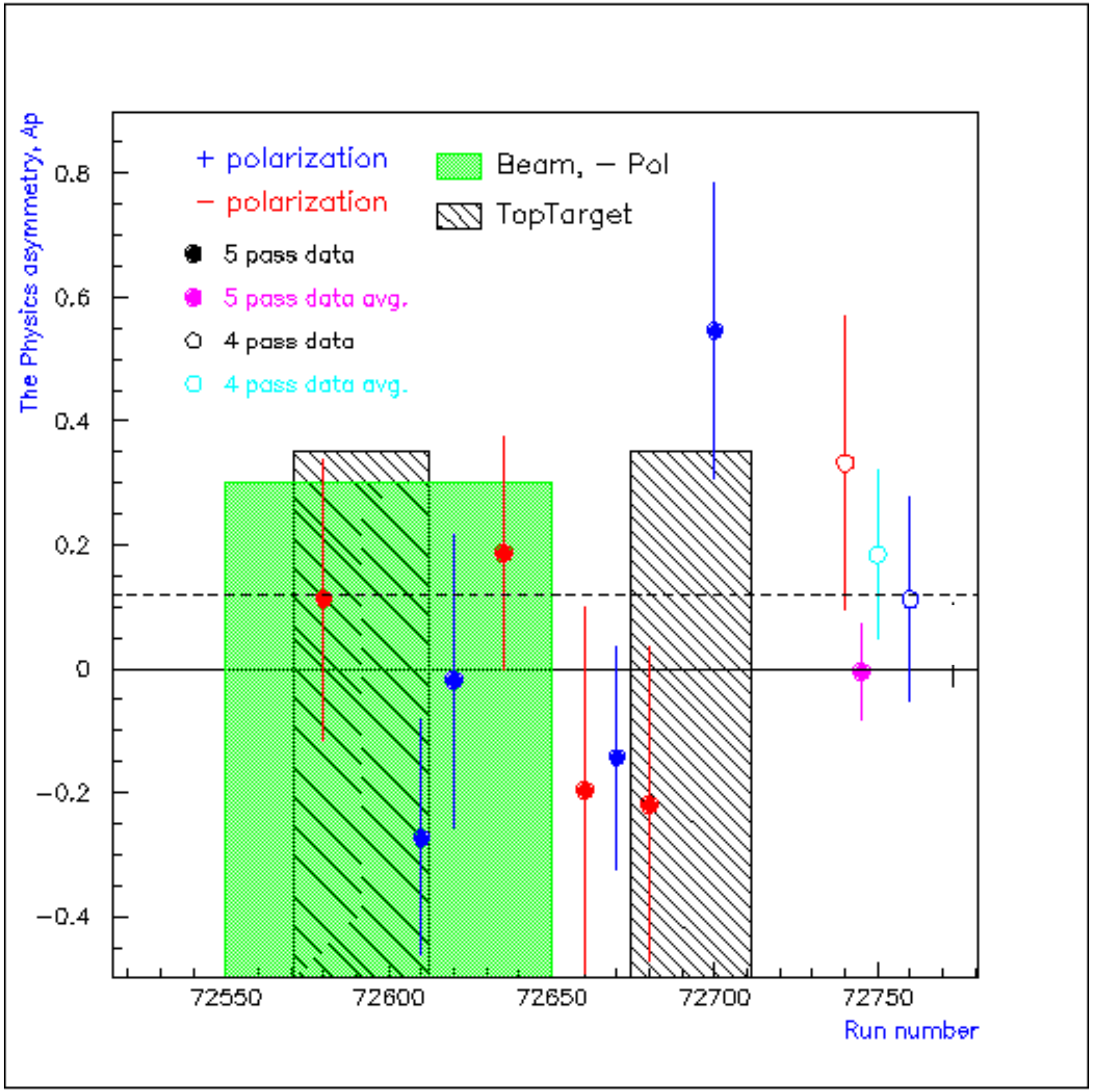
= (data-SIMC_C)_bot/data_bot
= 606-130/606
= 0.785

Beam and Target Polarizations

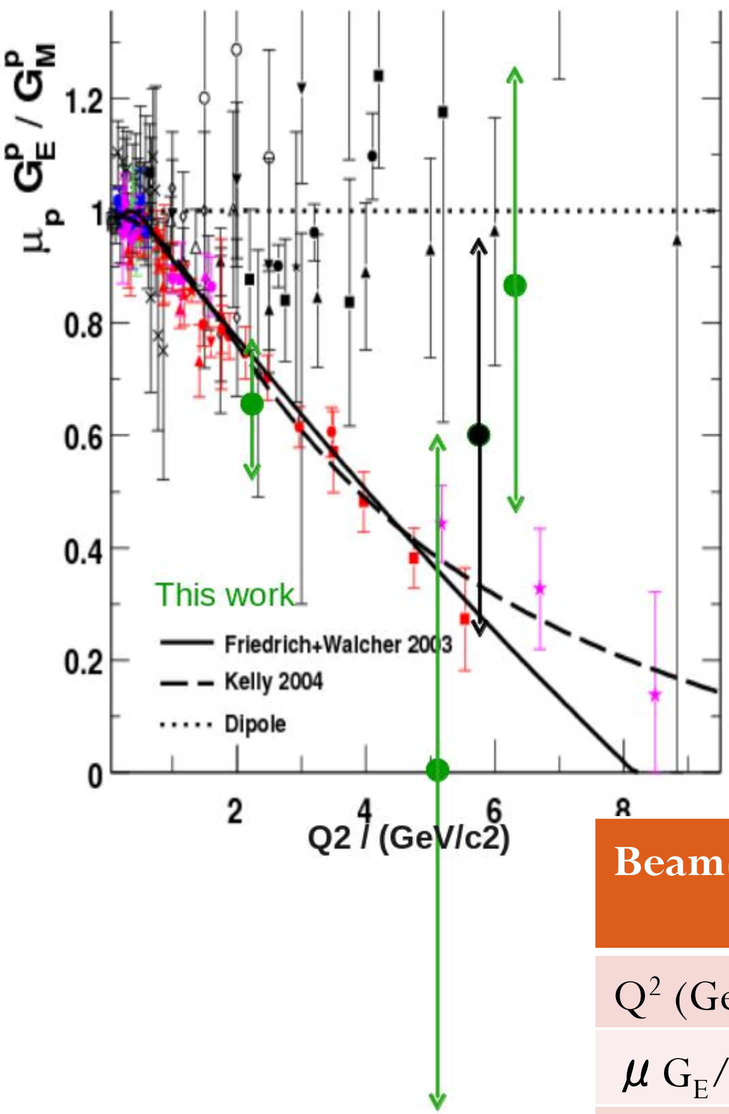


- Used the runs of beam polarization > 60 % and abs(target polarization) > 55 %
- Used the charge average target and beam polarizations to calculate the physics asymmetries

Extract the Physics Asymmetries



Extract the Form Factor Ratio, G_E/G_M



Beam(GeV)	4.72	5.89	Weighted Avg.
Q^2 $(GeV/c)^2$	5.17	6.26	5.72
μ G_E/G_M	-0.032	0.875	0.6145
$\Delta(\mu$ $G_E/G_M)$	0.668	0.424	0.358

To Do

- Determine the new dilution factor, raw/physics asymmetries and hence the form factor ratio, G_E/G_M using the new packing fraction of 56.3% for the single arm electron data.
- Estimate the systematic errors for both single arm electron and coincidence data

Conclusion

- Measurement of the beam-target asymmetry in elastic electron-proton scattering offers an independent technique of determining the G_E/G_M ratio.
- This is an 'explorative' measurement, as a by-product of the SANE experiment.
- Extraction of the G_E/G_M ratio from single-arm electron and Coincidence data are shown.
- The preliminary data point at 2.2 $(GeV/c)^2$ is very consistent with the recoil polarization data (falls even slightly below it)
- The preliminary weighted average data point of the coincidence data at 5.72 $(GeV/c)^2$ consistent with the recoil polarization data within it's 3 σ error.

SANE Collaborators:

Argonne National Laboratory, Christopher Newport U., Florida International U., Hampton U., Thomas Jefferson National Accelerator Facility, Mississippi State U., North Carolina A&T State U., Norfolk S. U., Ohio U., Institute for High Energy Physics, U. of Regina, Rensselaer Polytechnic I., Rutgers U., Seoul National U., State University at New Orleans ,Temple U.,Tohoku U., U. of New Hampshire, U. of Virginia, College of William and Mary, Xavier University of Louisiana, Yerevan Physics Inst.

Spokespersons: S. Choi (Seoul), M. Jones (TJNAF), Z-E. Meziani (Temple), O. A. Rondon (UVA)

Thank You